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Ethnoastronomy and Archaeoastronomy in the American Tropics

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Introductory Remarks

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MORE THAN FORTY years ago, a specialist on the culture of the Indians of Peru concluded his summary of indigenous cosmological ideas with the statement that they were fragmentary and unsystematic and were not brought into relationship to rituals or everyday life. Today, working in the field with a different set of theoretical assumptions, we are able to see that the "fragmentary" nature of American Indian cosmology is perhaps only an artifact of our incomplete understanding of the principles along which indigenous populations of the Americas organize phenomena perceived in their environment. The example we have used concerning Peruvian Indian cosmology is echoed in works related to the cosmologies and systems of precise knowledge of Indian populations throughout North and South America. In light of this, it is important to be reminded as we begin this conference that our theme reflects a new, and in a sense revolutionary, set of assumptions in the study of American Indian culture. That is, our fundamental concern here is not how closely American Indian epistemology conforms to that of the western world. Nor are we primarily concerned with whether or not American Indian systems of astronomy and cosmology constitute a "science." These are, of course, concerns of some interest, but only in so far as they allow us to define more precisely the boundaries of our own forms of thought and logic. In this conference, we are exploring, in a comparative perspective, the traditions of thought and logic whereby American Indian cultures in the tropics organize cycles and phenomena perceived in their terrestrial and celestial environments. If these systems of knowledge are found to be similar to the systems of those cultures located in northern, temperate, latitudes, then we will learn something of the cognitive unity of mankind. If they prove to be dissimilar, then we will be reassured of the human capacity for change and

adaptation to diversity. Whatever the conclusions, and we suspect they will be mixed, we will have learned something important about American Indian culture and about our own abilities for exploration and synthesis of new knowledge.

But this synthesis is a far more difficult task now than at any time in the past. Thirty years ago, Lord Snow offered a serious criticism on developments at the frontier of human knowledge: he suggested that, as a result of intense specialization, sheer weight of content, jargon, and a lack of communication, the domains of human inquiry – the arts, literature, and the sciences – had begun to drift apart. They float, he said, like islands in a vast sea of knowledge separated by a gulf of mutual incomprehensibility.

This conference is dedicated to building bridges across those gulfs. For, while we all gather as specialists and representatives of our disciplines – as art historians, archaeologists, architects, anthropologists, astronomers, and historians of science – we also share the commitment to pursue a fuller understanding of non-Western cultures, both present and past. Specifically, we seek to comprehend their view of the natural world, a view that might not necessarily mirror our own.

For those in the audience who are unacquainted with our endeavors, the operating premise of the interdisciplinary fields of archaeo- and ethnoastronomy can be stated quite simply: Because most ancient and contemporary non-Western civilizations tightly integrated their view of the universe with other facets of human endeavor – with art, religion, agriculture, architecture, and social structure – we believe that we can understand their outlook only when we patiently assemble all the relevant parts of a wonderfully complex harmonious puzzle. When those of us operating at one end of the cultural puzzle find pieces of the picture at the other end a bit too out of focus, we call for a description of the remoter parts from those who are near enough to see them more clearly. Accordingly, the audience will witness cross-disciplinary interaction at several levels, all of which we hope will lead to a better collective understanding of the role of astronomy in native American tropical cultures. The papers on Mesoamerican and South American astronomical systems will provide a genuine opportunity for comparative area studies. Although both are often called "Americanists," scholars interested in these two Americas are rarely offered a chance to compare notes on topics ranging from methodology to cross-cultural diffusion. Likewise, ethno- and archaeoastronomy offer a contrast of present with past and a chance to forge evolutionary links.

We would like to thank the New York Academy of Sciences for supporting this venture, which, judging by the quality of the participants, is sure to pave new paths to the understanding of tropical systems of thought. We also thank the Hayden Planetarium of the American Museum of Natural History for the demonstration-workshop, at which many of the celestial phenomena discussed at the conference were seen acted out on the planetarium sky.

We also thank Prof. Ralph Solecki, who initially encouraged us to approach the Academy with the proposal for this conference, and the conference committee, Drs. Lucy Saunders, Bruce Chandler, and Kenneth Franklin. Thanks are also due the editorial staff of the Academy: Bill Boland, India Trinley, and Frederick H. Bartlett.

Woven Heaven, Tangled Earth

A Weaver's Paradigm of the Mesoamerican Cosmos

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IN RECOUNTING the tribulations of the Yucatec Maya at the hands of their Spanish conquerors, the author of the Chilam Balam of Tizimin has written

> Once there was truth, which we drew from the Serpent in ancient times, from the clear unclouded heavens to the evil-knotted earth beneath. But when the enemy warriors came, the folds of death became the swaddling clothes of our babies. . . . Now it should be said of the four gods that they stretched out the earth. And when they had finished stretching out the earth, they planted the red *Imix* tree.[1]

The Tizimin passage is notable for its reliance on metaphors that present Maya time and space in terms of a pliant substance that, given the allusions to knots, swaddling clothes, and folds, is here surely some sort of fiber or fabric. Its reference to "the stretching out of the earth," which the text dates to the creation, evokes an image of the weaver who readies the warp cords on her loom. The reference recalls the Tovar Calendar commentary on the Aztec month Tititl, which it translates as "Stretching," for which it depicts "a man as one who stretches something with a cord, in order to indicate that the gods thus stretch and sustain the machine of the world. . . ."[2] Kubler and Gibson note that Tititl was frequently identified with the rites of weavers.[2] Although the ancient Mesoamerican cosmos has been described by Walter Krickeberg in terms of two bottom-to-bottom, essentially identical masonry pyramids,[3] the Tizimin and Tovar texts strongly suggest that, for some at least, it was constructed not of stone blocks, but of filaments. The Tizimin descrip-

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tion of the earth as "evil-knotted" further implies that the exact arrangment of the "strands of the universe" varied according to their location and their connotations. If this is a representative description, then the various parts of the Mesoamerican universe were each conceived in terms of a different product of the spinner or weaver.

THE SACRED CORDS

Both art and literature testify to a general Mesoamerican belief that the universe is bounded, defined, and contained by long, thin, essentially supple objects of a basically cord-like form. The primary identity of these strands varies, but the various types are typically cross-connected. Since their common function lies in their ability to connect disparate points and thus provide a means of passage and communication, many are ostensibly topographic. The Lacandon myth recorded by Tozzer of a primordial "road suspended in the sky" that once channeled food to the living exemplifies numerous references to a universe bound by interconnecting paths or roads.[4] Today, the Chamula, for example, claim that their cosmos "is bounded and held together by the circular paths of the sun and the moon . . .,"[5] and the Lacandon tell of the sun's daytime travels along a road in the sky.[6] For the Tzotzil studied by Holland, the celestial path is made of flowers,[7] while, for the Cuicatec, the sun's return trip though the underworld is now made by rail.[8] Aztec texts are rife with references to roads and paths through the sky and underworld, and rows of footprints were a favorite pre-Hispanic pictorial device.

In his study of the iconography of the Tulum murals, Arthur Miller argues that the Lacandon sky road was equated with the human umbilical cord, since the former was described to Tozzer as a giant rope that passed nutrients in the form of blood.[9] According to Edmonson's translation, the Popol Vuh creation story mentions "the rope of tying together, the line of tying together" in relation to the wombs of heaven and earth.[10] A comparison of roads with such internal pathways of the body is not illogical, and may even have been extended to other organs seldom romanticized by us. Removal of the food-channeling intestines, for example, was an important part of postmilitary rites among the Classic Maya and the inhabitants of El Tajín, and the intestines are usually depicted as twisted, like rope (FIGURE 1).[11] Several of Miller's visual illustrations of alleged umbilical cords in fact emanate from gaping stomach wounds in figures who are clearly quite dead.[12]

While the pre-Hispanic symbolic significance of the intestine may forever escape us, it is worth nothing that Sahagún's Aztec informants

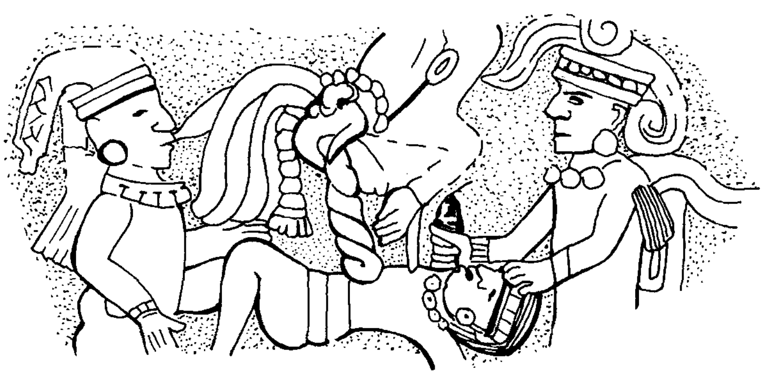

FIGURE 1. Removal of the intestines of a sacrificed war captive. Building of the Columns relief, El Tajín, Veracruz. Stone. Classic period. Drawing by the author after E. PASZTORY,[11] p. 211 (fig. 21).

said of the stomach, "it stretches, it extends."[13] Sahagún, moreover, refers to the intestine as *coatl*, or "snake."[13] The extension of the concept of the filament to the animal world is well known, thanks to Miller's work on the twisted and interlaced serpents who define the registers of the murals at Tulum.[14] Interlaced pairs of serpents similarly form the borders of several murals at Classic Teotihuacán,[14] and decorate the upper surface of a ballgame ring from Chichén Itzá.[16] A single undulating snake, its head and tail often entwined, defines or contains spaces and objects in the Maya Codex Madrid.[17] The notion that the strands that define and contain the entire universe are composed of serpents survives today in several places. The Huichol, for example, believe that a giant two-headed serpent surrounds the world.[18] The concept surely relates to the Classic Maya paradigm postulated by Thompson, in which the outstretched bodies of four giant reptiles called Itzam define the top, the bottom, and the four corners of the cosmos.[19] Four snakes, according to the Ritual of the Bacabs, were indeed the agents of creation who formed the world.[20] The Maya glyph for sky, *ka'an*, also served for the number four, and is very close to *kan*, the word for snake.[21] Thompson further observes that the Maya of Socotz, Belize, refer to cords and hammocks as *k'an*, and say that snakes resemble the cords of a hammock.[22] *K'an*, according to Bruce, applies among the Lacandon to all stretched strings or cords, and "thus evokes the concept of *xukut*, the cords the creator gods stretched to mark the four points of the compass. . . ."[23]

THE HEAVENLY HOUSE

The Mesoamerican universe, then, was perceived, at least by some, as formed during the creation with pliant cords stretched out as on a giant loom. Thompson, however, describes the celestial portion of the Maya universe, not as a loom, but as a house, since the reptilian Itzam who enframe it were collectively known as Itzam Na, "Iguana House."[19] Thompson's reading is paralleled by Sahagún's report that the Aztec, too, "thought and took as truth that the heavens were just like a house" that extended to the edges of the sea "in every direction."[24] In the Mixtec Codex Nuttall 75, the sky rests like a lintel on a support beam like those that hold up the roofs of temples and houses in the same manuscript.[25] Vogt found the Zinacanteco house serving as a microcosm of the upper universe, its peaked roof thought of as layered and traversed by the sun, moon, and stars.[26] Exactly what material the cosmic paradigm was thought to be made of is not reported, but the Zinacantecos call the umbilical cord the "house of the baby."[27] The Aztec, in contrast, seem to have perceived the heavenly mansion as built of walls of water. "It was as if the water walls were joined to it," writes Sahagún, "and hence they called it 'water which reaches the heavens' because it stretched, extending to the heavens."[24] The Aztec sky was called *ilhuicatl*, the ocean *ilhuicaatl*, or "sky water".[24] The term *ilhuicatl*, "sky," was also used for the binding wall beam used in actual building.[28] Sahagún says that "it bears everything . . . it carries—it completely carries [the superstructure]."[28] Aztec house façades were also called *ilhuicatl*, and Sahagún's illustration of their wall beams shows that they were bound together with cords that form a diagonal cross.[29] The resemblance of these lashings to the well-known crossed-bands glyph is significant, given Thompson's opinion that the glyph corresponds to the Maya *kat, cat*, or *kaat*, the latter of which "means something transverse or oblique, and is used for such actions as placing a beam transversely, and crossing from one side to another."[30] The crossed-bands glyph, as often noted, appears infixed at the upper end of the rear support beam of Maya structures in the Dresden Codex,[31] and has been variously associated by scholars with water, the serpent, the underworld, and, traditionally, the sky.

The concept of the upper universe as a house is by no means inconsistent with the postulated model of weaving, since ordinary Mesoamerican houses are, even now, essentially woven. Wattle and daub structures, in particular, qualify here, since their cane armatures were literally constructed like fabric (FIGURE 2). Wauchope heard the walls of such houses referred to by Maya names that mean "to be woven or braided," "to be in-

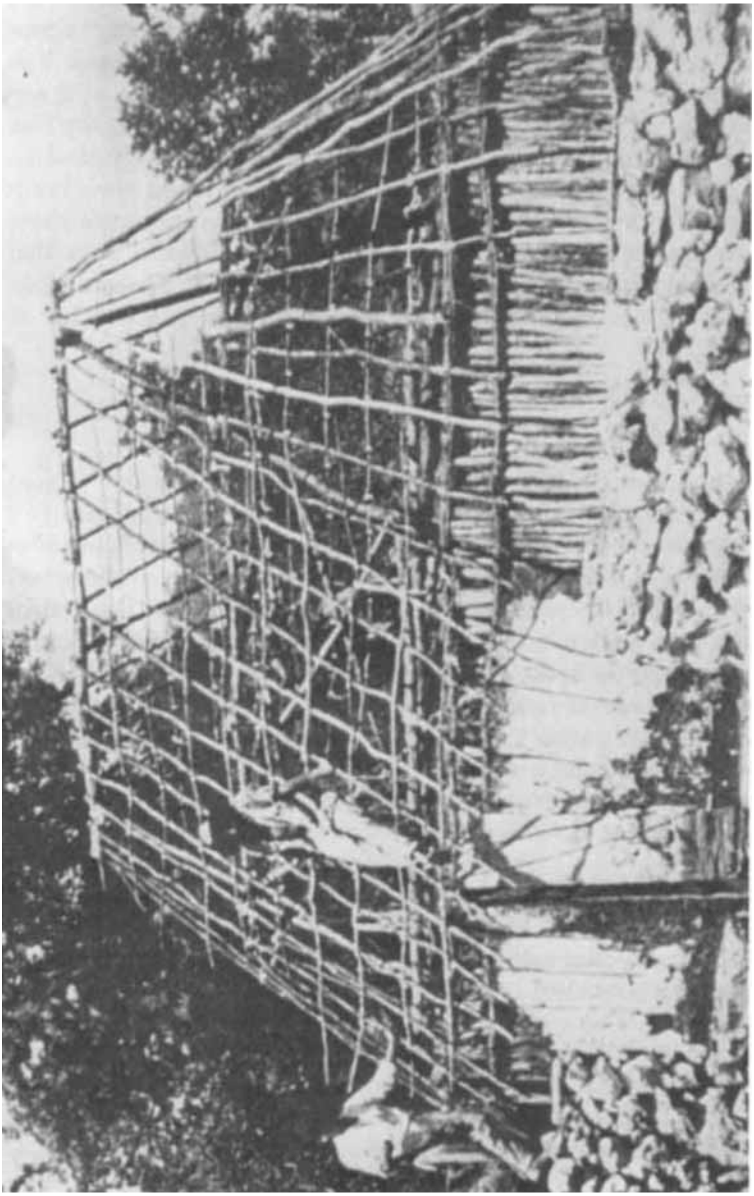

FIGURE 2. Contemporary Maya house under construction. Isabel, México. Wood and thatch. From F. ROBICSEK, *Copán: Home of the Mayan Gods* (New York: Museum of the American Indian, Heye Foundation, 1972), p. 41 (fig. 32), by permission of the author.

terwoven as in a braid or mat," "a cord with which they fasten the cloth," and "to twist cords, double, and twine them."[32] Maya houses are measured and their parts matched by means of a stretched cord,[33] a process that curiously parallels Recinos' translation of the Popol Vuh reference to the Maya creation as a time when "the measuring cord was brought and . . . stretched in the sky and over the earth, on the four angles, on the four corners."[34] Twisted cords and vines literally bind the various parts of a Maya house together.[35] Among the Aztec, these cords may have been made of *malinalli,* a wild twining grass whose name derives from *malina,* "to twist something," since Peñafiel says that *malinalli* was used to make carrying sacks and cords.[36] Siméon thinks that *malinalli* was braided "without doubt for the construction of houses."[37]

THE TWISTED EARTH

The celestial house, then, was conceived of as woven, its various elements integrated in an orderly fashion. The basic structural members were organized according to the geometric principle of the grid, in which vertical elements interweave with horizontal ones. The house, however, is itself but a shell or container that, by definition, encloses and defines essentially empty space. For the Mesoamerican, the concept of the upper world as uncluttered space is expressed in the Tizimin reference to the clear unclouded heavens over the evil-knotted earth beneath. During the day, only the sun passes through this vast expanse, traveling along a single road that is fundamentally straight. Only at night is that space crowded with the numerous twisting paths of the moon, stars, and planets, which must have been perceived as forming a giant tangled web or net.

Krickeberg claims that the Aztec, at least, believed that the stars of the night sky represented or reflected their ancestors dead in the underworld.[38] The idea is important, for it would suggest that the underworld itself was conceived as a crowded, tangled skein or net. The notion may lie behind Vogt's observation that the square-plan Zinacanteco house represents "the sane, systematic, well-ordered world of culture, as opposed to nature" and the round, disordered realm of the Earth Lord below.[39] The Zinacanteco house has to be continually protected against the threatening underworld beneath its floor, which, for the Chamula, is laced with water-filled caves and tunnels that twist and turn in all directions.[40] The image is literal for the Maya, who live on a karst-type lime-

stone shelf, but the Post-Classic Central Highlands Mexicans apparently shared it. "For the sea enters within the land," writes Sahagún, "its water passages, its ducts stand; they extend. It goes in all directions within the land in the mountains."[24] The association of multidirectionality, here ascribed to crowdedness and clutter, is reflected in the Zinacanteco belief that the Earth Lord has "multiple manifestations."[41] This property allows him to appear at any opening in the earth's surface, an option reported for the Aztec earth and water deity Tláloc, as well.[42] The Chilam Balam of Tizimin refers to the "many roads that lead to death" during times of injustice, and contrasts the obviously straight and vertical "good roads" by which the dead can ascend quickly to heaven, with the "evil roads" that descend, "spreading out on the earth."[43] Ultimately, the latter led to the land of the dead in the thick of the underworld, a place described by Sahagún as having "no outlets and no openings."[44]

The image evoked is that of a dense wad or ball of tangled strands, some of which emanate out and upward in a slow, tortuous fashion. The disordered convolutions of the underworld are, in fact, very apparent in Maya paintings in particular, a number of which date back to the Classic period. The twisted, interlaced, assymetrically arranged snakes of the famous Black Background Vase, according to Jacinto Quirarte, support and convey various inhabitants of the Mayan underworld (FIGURE 3).[45] Thomas Barthel draws essentially the same conclusion from the undulant serpents on a tripod plate from Uaxactun.[46] The upper serpent there takes the same arched form adopted by the snake above Adams' figure 4 on the Altar Vase, which Adams identifies as a symbol of a completed life cycle.[47] Snakes of similar configuration appear throughout the Madrid Codex in association with gods of water and death,[48] and the Aztec earth and death goddess Coatlicue, or "Serpent Skirt," can be identified by her skirt of braided serpents. In the pre-Hispanic images, the serpents are intertwined in an orderly manner,[49] but Sahagún's artists represented them as wildly entangled.[50]

As Cihuacóatl, the "Snake Woman," Tlaltecuhtli, the "Earth Lord," and Mictecacíhuatl, "Lady of Mictlan," the Aztec land of the dead, the same goddess is further portrayed with wild, tangled hair.[51] In some cases, it seems to be made of *malinalli*, which is twisted in its natural state, as its name suggests. The wild hair of her modern Cuicatec counterpart is described by Hunt as symbolic of her evil, uncivilized ways.[52] The Cuicatec version is called Matlacíhuatl or Maxtlicíhuatl, both Nahuatl names, the first of which is based on the root *matlatl*, or "net." Hunt interprets it as a reference to snares or traps, pointing out

FIGURE 3. The tangled serpent-cords of the Maya underworld. The "Black-Background Vase," detail. Provenance unknown. Classic period. From F. ROBICSEK,[27] p. 167 (fig. 153), by permission of the author.

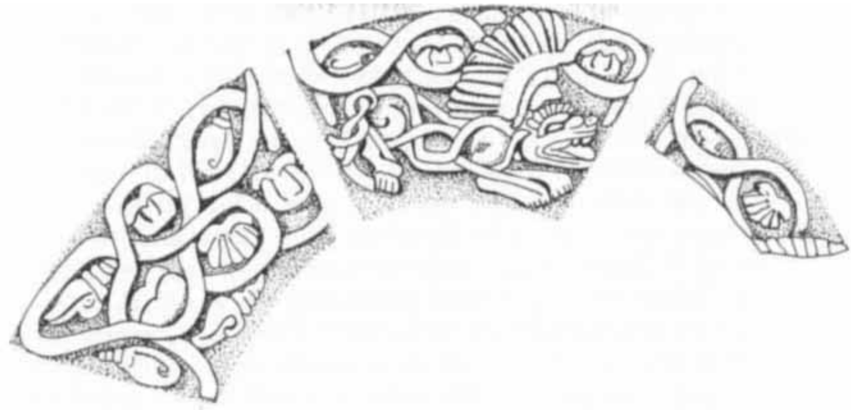

FIGURE 4. The Net-jaguar in the watery underworld. Relief on a Teotihuacán bowl fragment from Santiago Ahuizotla, México. Clay. Classic period. Private collection, Los Angeles. Drawing by the author after H. VON WINNING,[54] p. 42 (fig. 10).

that the creature's Spanish name, Mujer Enredadora, means "Ensnaring Woman."[50] The reference is intriguing, given the consistent appearance of nets and netted creatures, especially jaguars, in the context of a watery underworld in the imagery of Teotihuacán (FIGURE 4). Nets and knots frequently appear on the underworld deities of the Maya,[53] and priests of the old Aztec earth and water lord Tláloc wore special netted capes, as von Winning points out.[54] While the form of the net may strike us as just as orderly as that of a weaving, it must be recognized that the structural principle is by no means the same. While the many threads of the weaver are kept essentially straight on either a horizontal or a vertical, but never both, the single cord of a net constantly reverses direction along zigzagging diagonals.

Sometimes, the undulant forms that describe the underworld are aquatic plants; in other instances, the material cannot be identified. What seems to have mattered was not the substance, but its unruly condition. The Popol Vuh describes the jaguars of hell, for example, as "all tangled up . . . squeezed together in a rage,"[55] while one Aztec god was named Acolnahuácatl "The One from the Twisted Region," according to Caso.[56] Tláloc was often depicted with a face formed of twisted serpents,[57] much as the Mayan underworld lord, the Jaguar Night Sun, often wears a twisted nose cruller, if not a long twisted scarf.[58] Elizabeth Benson suggests that twisted fabrics in general may have signified the underworld in the art of the Classic Mayans.[59] The metaphor evidently

extended to illness, as the Tarascans equated poor health with "twistedness,"[60] and the Chilam Balam of Tizimin speaks of "the twisted earth" of the period of Mayapan's "affliction."[61] The Huichol sick, according to Lumholtz, are literally seen as in need of "disentangling."[62] The image recalls the operations of the *mecatlapouhque*, the Aztec diviners and healers who used bundles of tangled or knotted cords for their prognostications. If the cords remained entwined after being thrown to the ground, death was predicted for the ailing; if they unraveled, recovery was expected.[63] The image apparently extended to time itself: the Chilam Balam of Tizimin mentions several omens that "appear black indeed, because of the entanglement of the katun."[64] Peter Furst reports that, among the Huichol, knots in a cord are untied one by one as each day of the peyote pilgrimage passes.[65] The Aztec, as is well known, bound and cremated 52 reeds symbolizing years at the end of each 52-year "century." A popular graphic symbol of this event, as seen on the balustrade of the miniature Pyramid of the Sacred War, included a twisted and knotted cord.[66]

The belief that the underworld is composed of a wad of entangled strands may help explain the association of tangled hair and cords with priests and "penitents" engaged in rituals of death and/or fertility. Durán, for example, refers to ropes connecting five trees set up in honor of Tláloc at the five world directions during Huey Tozoztli as "cords of penance" representing "the penance and harshness of the life led by those who served the gods."[67] Since they were made of "twisted straw," they may have been made of *malinalli*. Among the Aztec, it was the priests of Tláloc who regularly performed self-sacrifice and sacrifice of others and at least one of them, the chief sacrificer, wore a wig of *malinalli*.[68] The real hair of the other priests was reportedly never combed, and was always matted with blood. Both the twisted cords and the tangled hair may have symbolized the disordered filaments of the underworld. In the Maya Codex Madrid 19b, moreover, five deities pass a common twisted cord through their swollen organs that takes an arched, irregular form reminiscent of the underworld serpents in the same manuscript.[69] Certainly, use of the cords that compose the underworld to draw fertilizing sacrificial blood would have been entirely appropriate, and it may well be those cords that are alluded to in Classic Maya reliefs of elite persons passing cords through perforations in their tongues, their ears, and, if male, their virile members.[70] Either sacrifice or punishment is implied by the curious rack of tangled cords in the Building of the Columns reliefs at El Tajín, from which a man is uncomfortably suspended, head down

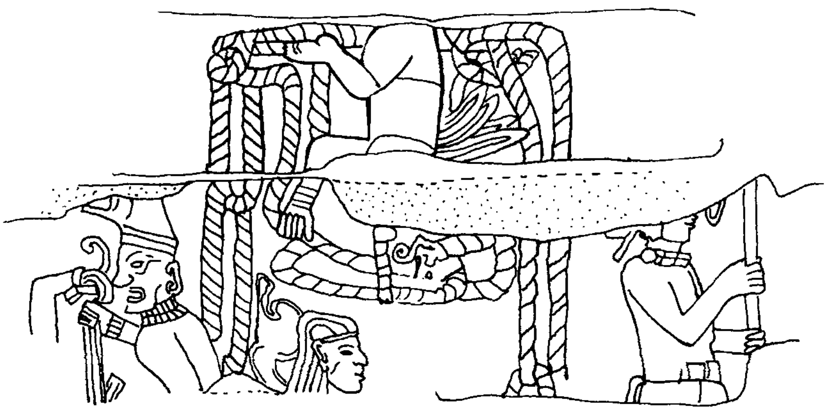

FIGURE 5. The tangled cords of the underworld as a "rack of punishment." Building of the Columns relief, El Tajín, Veracruz. Stone. Classic period. Drawing by the author after D. TUGGLE,[71] pp. 58, 59 (fig. 6).

(FIGURE 5). Tuggle suggests that the scene is set in the underworld of the Tajín rain god.[71] The image may relate to that in Codex Madrid 35, in which two figures are similarly suspended upside down, one from a rack of braided cords.[72] Since the Mesoamerican sacrificed were often war prisoners, the close association of sacrifice with punishment can hardly be questioned. The direct association of misbehavior with entwined cords is found in the Huichol custom of making a knot in a cord for each past marital transgression of their peyote pilgrims.[65] Bad people, says the Chilam Balam of Chumayel, sit "crookedly on their thrones; crookedly in carnal sin," and they "twist their necks" as well.[73] For the Tarascans, wrongdoing was described as "twistedness,"[60] and an Aztec poem equates envy with a "twisted heart."[74]

In contrast to the neatly woven house of the upper cosmos, then, the model for the Mesoamerican underworld was a tangled, knotted wad or ball, whose loose ends connected with the openings in the surface of the earth (FIGURE 6). The earth's surface, moreover, was similarly envisioned in terms of filaments that, in at least some cases, were interwoven to form a giant piece of cloth. During the creation of the earth, for example, "the paths of the waters," according to the Popol Vuh, "were unraveled . . . to twist along among the hills" and become "more divided."[75] Other texts imply that the earth's crust was perceived as badly wrinkled. The Chorti report that "long ago, there were no mountains on the world . . . because the world was once stretched over the water."[76] The implication

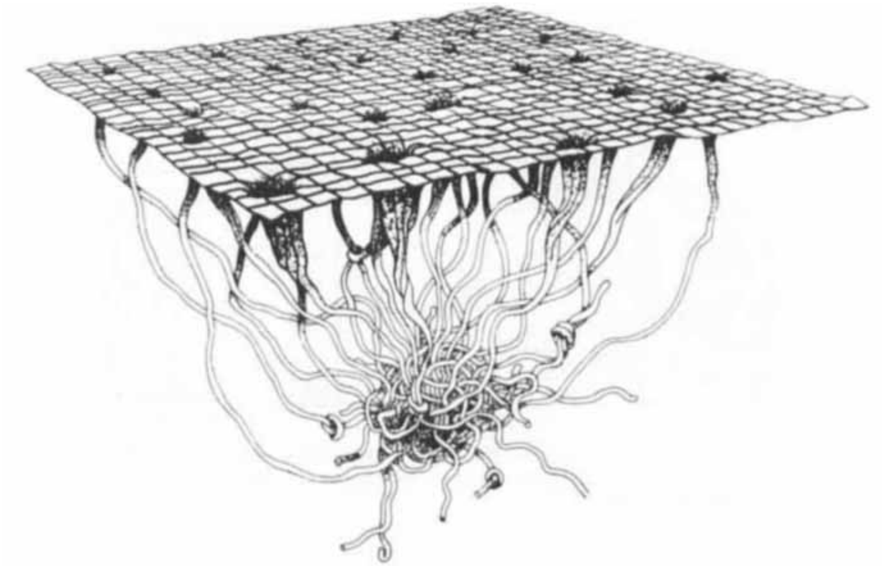

FIGURE 6. The woven earth and the tangled underworld of the Mesoamerican cosmos: a model. Drawing by Henry F. Klein.

that the originally flat earth subsequently contracted fits with the Tovar Calendar commentator's explanation that the gods originally stretched "the machine of the world" "so that the violence of the winds [might] not destroy it."[2] Caso offers *arrugado*, "wrinkled" or "crumpled," as an alternative translation of the name of the month in which this event was commemorated.[77] Tititl fell, in fact, according to the Tovar commentary, between December and January, "when the winds here are very severe."[2]

THE COSMIC SEAM

The actual juncture between the sky, earth, and underworld was, of necessity, localized. The Aztec seem to have believed that the sky meets the ocean edge at every point along the circular horizon,[24] while the Tzotzil of Larrainzar, for whom the entire universe is a cube, believed that heaven and earth are joined only at the four corners.[78] The Yucatec, on the other hand, say that *chun caan*, "the bottom of the sky," is located in the east alone.[79] Here sit the Chacs, or rain gods, who issue forth to take up position at the four world directions from a cosmic doorway in the cloud layer at this "foot of the sky."[79] The Chorti, however, say that,

FIGURE 7. The interlaced two-headed cosmic serpent. Huastec. Engraved and pierced shell. Post-Classic period. Middle American Research Institute, Tulane University. From R. WAUCHOPE, *Handbook of Middle American Indians*, vol. 11 (Austin: University of Texas Press, 1971), p. 596 (fig. 2), by permission of the publisher.

FIGURE 8. The interlaced two-headed cosmic 'dragon,' Altar O, Copán. Maya. Stone. Classic period. Drawing by the author after M. COVARRUBIAS, *The Eagle, the Jaguar, and the Serpent* (New York: Alfred A. Knopf, 1954), fig. 19, below.

at this place, the sky and the sea are "stuck together."[80] For them, the solder is tar, but, in pre-Hispanic times, the two parts of the cosmos were either woven or sewn together. The Chorti still say that "the world and the sky are like the back of a wasp, coming together at a joint."[81] Viewed from above, the wasp's back is constricted at the center, in a form not unlike that of an hourglass. The basic structure appears often in Mesoamerican codices in particular, and is engraved on a Huastec shell as a two-headed, interlaced serpent (FIGURE 7). While the lower portion of the snake's body encircles a body of water, its open-mouthed upturned heads support a female and a male engaged in ritual bloodletting. There is no direct evidence that the serpent's body contains the watery underworld, its upturned heads forming the earth's surface or heavens, but the Maya Itzam Na, often portrayed as a two-headed reptile, is sometimes depicted with an interlaced or twisted midsection (FIGURE 8). According to the Histoyre du Mechique, the Aztec believed that the sky and earth had been formed when one god grasped the right arm and left foot of the earth monster, another her left arm and right leg, and violently twisted her into two parts at the middle.[82]

The image of a bipartite universe interlaced at the middle is reflected in the Mesoamerican game of Patolli, as reconstructed by Kendall after ethnographic accounts of the game played today in rural Puebla. The game's most surprising feature, says Kendall, is the track the two players

followed, for, as each traversed only three of the four arms of the Aztec form of the playing field, their pieces met only in the "no man's land" at the middle.[83] In the Mixtec manuscript depictions of the Patolli playing board, this central section is marked by an interlace created either by the twisted cords that seem to have formed the field itself, or by those that made up the enigmatic *ollin* symbol.[84] *Ollin*, "movement," is related to *olli*, "rubber," which, when liquid, is sticky, like tar.

For the Aztec, this place at the middle was the home of the dual god Ometeotl, "The Lord Two," who simultaneously dwelled in the clouds and the waters. Although the two deities—one male, one female—who composed Ometeotl are never depicted as entwined, their role as the mother and father of both the gods and all living things implies a pretty constant embrace. Aztec poems, in any event, regularly describe their abode in such terms. Of the myriad fragrant flowers that adorn Ometeotl's home, one poet says, "they interlace, they interweave"; he describes this "house of flowers" as itself "interwoven."[85]

The concept of the interlace in relation to the join of heaven and earth implies the presence of a giant cosmic seam. The two parts of the universe must thus have overlapped. The fact that Ometeotl could simultaneously dwell in the heavens, earth, and underworld suggests that this was the case, and the Aztec cited the earth's surface as the first layer of both earth and sky.[86] The concept is clearly defined in the Aztec and Maya calendars, in which the final days of each temporal cycle also introduced the cycle to follow. Both peoples fused space with time, and thus located this point of temporal overlap at the eastern horizon. Here, at dawn, is the interface between night and day, death and birth, and, hence, end and beginning.[87] Conception and birth were accordingly compared to the acts of spinning and weaving; all Aztec and Maya creation and fertility goddesses were described as great weavers.[88] Today, Tzotzil grandmothers give spinning lessons to young women at winter solstice to encourage them to be good sexual partners to their husbands.[89] The infant emerging from the womb of the Aztec fertility goddess Toci in Codex Borbonicus 13 holds two interlaced cords apparently symbolic of childbirth or creation,[90] and the crossed-bands glyph that we saw marking the main joint of the heavenly house is accepted by Kelley as a sign for sexual union and marriage.[91]

Certainly the theme of creation and actual passage from one cosmic realm to another is typically expressed in terms of single or multiple filaments. Aztec myth tells of the god Tezcatlipoca descending to earth during the creation by means of a spider's thread,[92] but the more com-

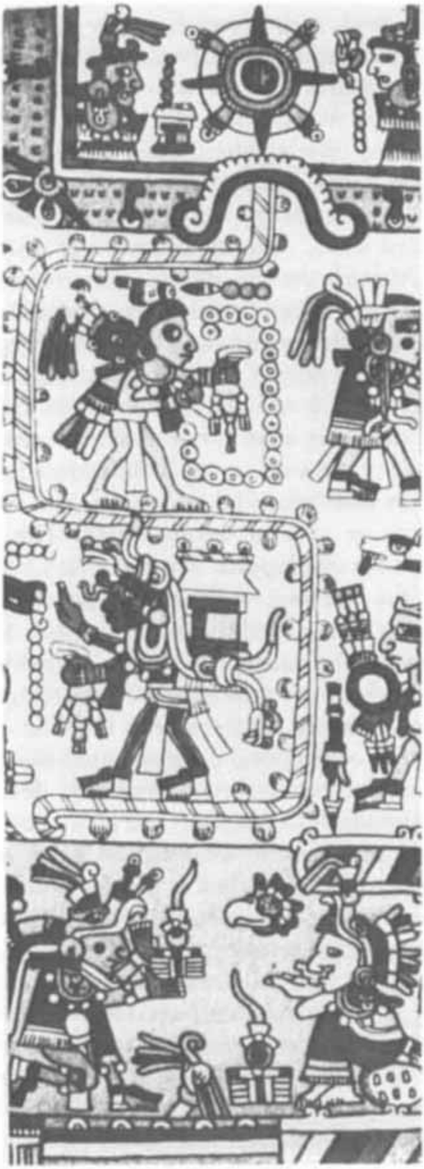

FIGURE 9. The Mixtec descent from heaven along the sacred cords. Codex Nuttall. Post-Classic period. From Z. NUTTALL,[25] pl. 18, detail.

mon vehicle is a twisted or braided cord. The Maya said, for example, that, at the beginning of a katun, "the rope shall descend, the cord shall descend from heaven."[93] In the Mixtec Codex Vindobonensis 48, as Jill Furst points out, the culture-hero "9 Wind" descends from heaven on a rope covered with cotton balls.[94] Comparable scenes appear in Codex Nuttall 16 and 19 (FIGURE 9). Furst compares these to the Huichol rite of the flying children observed by Peter Furst, for which a real cactus fiber cord, to which were tied small cotton balls, was stretched out in front of the participants. It is by means of this cord that the children magically travel to Wirikuta near the eastern ocean where, in the time of creation, "Sun Father burst forth."[95] Irene Nicholson, moreover, published an Aztec poem that reads: "I tie a rope to the sacred tree, I plait it with eight strands so that I—a magician—may descend to the magical house."[96] The same image is evoked when Zinacantecos suspend a rope from the center of their ceiling to mark the point of entry to the domain of, and place for offerings to, the wicked Earth Lord below.[97] That these vital cords were conceived of as weaving in and out along the edges of the two halves of the universe is never stated, but weavers often join two pieces of fabric by means of a single thread.

The magic cords, on the other hand, may have referred to a concept of a giant cosmic spindle. When the Aztec wished to sacrifice a captive during their equinocial month Tlacaxipehualiztli, they tied him to a rope emanating from a large, flat, round stone called *temalacatl*, or "stone spindle."[98] Kelley suggests that the Maya referred to the equinoxes, like the solstices, as *caan tab*, "the tying of the sky."[99] There are a number of Classic and Post-Classic images, in any event, of a pole or tree enwrapped by one or two spiraling snakes or vines in a manner similar to a loaded spindle (FIGURE 10). The nexus of the universe is often described as a flowering tree of abundance where, according to one Aztec poet, "there interlocks the thread of our life."[100] When the spiraling element is itself a plant, we can be fairly certain of its meaning: the Yucatec claim, for example, that the souls of the dead ascend this tree by means of a ladder made of vines or climbers.[101] The concept survives in the west as well, where the Huichol tell of a magical place where "one grabs hold of something, like vines, in order to swing yourself over, in order to climb up to the sky."[102]

Sahagún's informants described the roots and branches of the tree as "stretched out," "matted," "entangled," and "interlaced," while its trunk, they said, "twists," and "has knots."[103] A tree with an apparently twisted trunk appears on Izapa Stela 27, and entangled but fruitful vines and

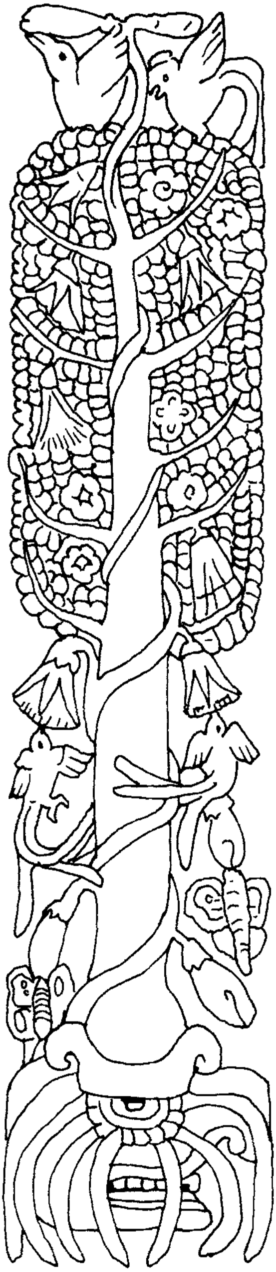

FIGURE 10. The Maya world tree (?) enwrapped by a spiraling vine. Balustrade relief, North Temple, Chichén Itzá, Yucatán. Stone. Post-Classic period. Drawing by the author after I. MARQUINA, *Arquitectura Prehispánica*, 2nd ed. (México, D.F.: Instituto Nacional de Antropología e Historia, Memorias, No. 1, 1964), fig. 30.

FIGURE 11. Interlaced plants growing from an anthropomorphized mountain. "Tlalocan Patio mural," Tepantitla, Teotihuacán. Classic period. Author's photograph of the reproduction in the Museo Nacional de Antropología, México, D.F.

branches recur in the stone reliefs of nearby Bilbao.[104] The famous tree of abundance that grows from the top of the personified mountain in the Tepantitla Tlalocán mural at Teotihuacán actually consists, as is often noted, of two entwined plants (FIGURE 11). If the tree was not always symbolic of the weaver's spindle, therefore, it was itself at times envi-

FIGURE 12. Netted hoop cult object and devotees. Teopanacazco mural, Teotihuacán. Classic period. From R. WAUCHOPE, Ed., *Handbook of Middle American Indians*, vol. 10 (Austin: University of Texas Press, 1971), p. 138. (fig. 6), by permission of the publisher.

sioned as woven. Trees and housepoles, moreover, provided the chief support for the ancient weaver's backstrap loom, and thus marked the implicit center of the woven cosmos.

THE PLAITED DOOR

There was a very special means of passage through the cosmos for those gods and men on whom the privilege was bestowed. The vehicle of transport was netted, plaited, or woven, and seems to have represented in sacred miniature the fiber universe of the Mesoamerican. During the Classic period, it took the form of a netted disk or shield that almost certainly referred to the sun. Such a netted hoop appears as a major cult object in the Teopanacazco mural at Teotihuacán, where it rests atop a kind of stand or altar attended by two well-dressed priests (FIGURE 12). In Mural 2 of Zone 5-A, Portico 18, a similar object serves as the face of an elaborately dressed, clawed feline figure, while in Zone 3, Mural 1 of Portico 2, Platform 15, it forms the body of Tláloc.[105] Pasztory would identify this as her Tláloc B, whom she links with the Night Sun in the netted underworld.[106] Since Tláloc B was further linked to the jaguar, the Mural 2 figure probably represents the Night Sun as well. A similar meaning can be postulated for the netted hoop set on a column in the El Tajín Building of the Columns reliefs,[107] and may apply to the netted cult object atop the earth monster head engraved on a peccary skull from Copán.[108]

The netted hoops of the Classic period are important because Peter Furst reports a Huichol belief that the youth who sacrificed himself to become the sun played a game involving a pole and a fiber hoop.[109] The game, as Furst points out, sounds very much like the widespread North American Indian game of hoop and pole that typically involved throwing a weapon at a hoop covered with a network of interlaced cords. Many of these hoops are woven in a cruciform pattern quite similar to the Aztec form of the Patolli playing board (FIGURE 13). Among some northern groups, the hoop represented the entire cosmos, but the Arapaho said that it stood for the sun as well.[110] During the Arapaho sun dance, such a hoop was first set up on an altar and then wrapped and hung up on a pole at the back of the lodge. Dorsey described it as "inviolably sacred" and reported that it was believed to be able to miraculously fly.[110] The concept is also reported among the Zuñi, in whose creation story Sun Father transported his children to the earth and underworld on a protective shield made of sacred netted cords.[111] Since the cords had

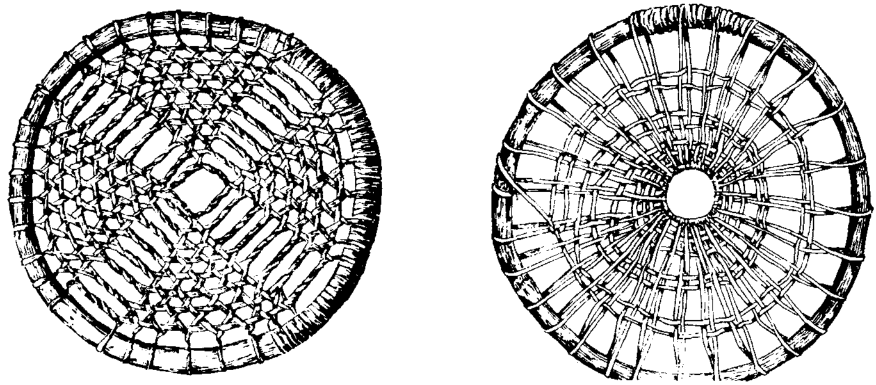

FIGURE 13. North American Indian netted hoops: left, Grosventre; right, Piegan. Wood, rushes. 19th century. From S. CULIN,[110] p. 447 (figs. 581, 582).

been spun from the clouds of the Zuñi sky-ocean, the shield was able to "float."[112]

It is significant that the Zuñi shield had a magical flint knife attached to it, because the Lacandon say that the sun always carries a bow and arrows to protect himself.[6] The Chinantec of Oaxaca[113] and the Maya author of the Chilam Balam of Tizimin[114] both refer to a spear or knife that protects the sun and his people. According to Codex Azcatitlan 11, moreover, the migrant Aztec safely fled from their early troubles at Colhuacan by crossing a river on shields that were netted.[115] Both the Aztec and the Maya conceived of the sun as a shield, and some Maya shields bore images of the sun's face.[116] In Codex Dresden 67, this face is replaced by a simple pair of crossed cords.[117] The point is important, because Thompson reads the Maya T116 glyph as *u tab kin*, "the sun's cords."[118] Kelley rejects the reading,[119] but a *kin*, or "sun," glyph with four radiating serpent heads terminates a long, interlaced, cord-like body in Codex Paris 17.[120] Twisted cords emanate from a solar disk in the Mixtec murals at Mitla[121] and decorate similar disks carved on both sides of an Aztec gladitorial stone (spindle) published by H.B. Nicholson.[122] Even today, the Otomí of El Zapote construct a woven palm-leaf ring to represent the sun, which they propitiate on Holy Cross Day for its protection.[123]

By the end of the Late Post-Classic period, the magical object appears to have been transformed into a mat or a woven throne. The interlaced object on the Classic peccary skull from Copán already took the form of a rectangular mat.[108] Among the Yucatec at conquest, as Thompson

points out, the mat, often reduced to a pair of interlaced bands, served the Maya as their glyph for the month Pop.[124] As the first of the months of the year, Pop was associated with the east, dawn, and creation, and was actually introduced during the final days of the preceding cycle.[125] The association was thus perfect for an object deemed capable of moving from one realm to the other. Mats, in fact, were typically plaited in such fashion that the strands involved seemed to be oriented in *all* directions. Sahagún's informants spoke of a curious object called *coapetlatl*, or *petlacoatl*, which they described as composed of many serpents assembled like a reed mat. "It goes, it travels, in this way," they informed him, "it runs back and forth; it runs in all directions, because the serpents' heads lie in all directions making the border of the serpent mat."[126]

The multidirectionality of the *coapetlatl*, like that of the world tree, contrasts with that of the tangled underworld by virtue of its positive meanings. He who managed to sit on it, Sahagún tells us, after some suffering "would then attain lordship or rulership."[126] Robicsek carefully documents the association of the mat with persons of political authority, noting that one of its roles in that regard was to serve as such persons' throne.[127] Like the netted hoops of the Zuñi, Arapaho, and Huichol, moreover, the Maya mat-throne was related to the sun. "They [the Spaniards] even go so far as to say," the Chilam Balam of Tizimin complains, "that there will not be a throne in the heavens, shining like the sun. . . ."[128] The throne, like the North American Indian netted hoop, clearly derived its importance from its ability to traverse the cosmos. Among the Tzotzil, the sun travels the heavens in a cart,[7] while, for the Lacandon, his mode of transport is a litter.[6] The Huichol sun passes daily overhead on a woven chair that was made at the creation to lift his weary body from the underworld at dawn.[129] Peter Furst relates the chair to the modern Huichol shaman's chair, the *'uweni*, which has a looped back that protects the shaman from sorcerers.[129] The seat of the *'uweni* is constructed of matted wickerwork, the type used by modern Maya to cover the entrances to their houses.[130]

The resemblance is probably not fortuitous, since, as noted earlier, the Yucatec speak of a cosmic doorway at the foot of the sky,[79] and since many ancient Mesoamericans conceived the entrance to the underworld in the form of a Maltese Cross. The Maltese Cross appears at times in Classic Maya art containing the same interlaced bands that form part of the Maya glyph for the month Pop.[131] In many Olmec, Classic Maya, and Aztec images, this Maltese Cross-shaped entrance to the tangled underworld is represented as the gaping mouth of the earth monster.[132] A

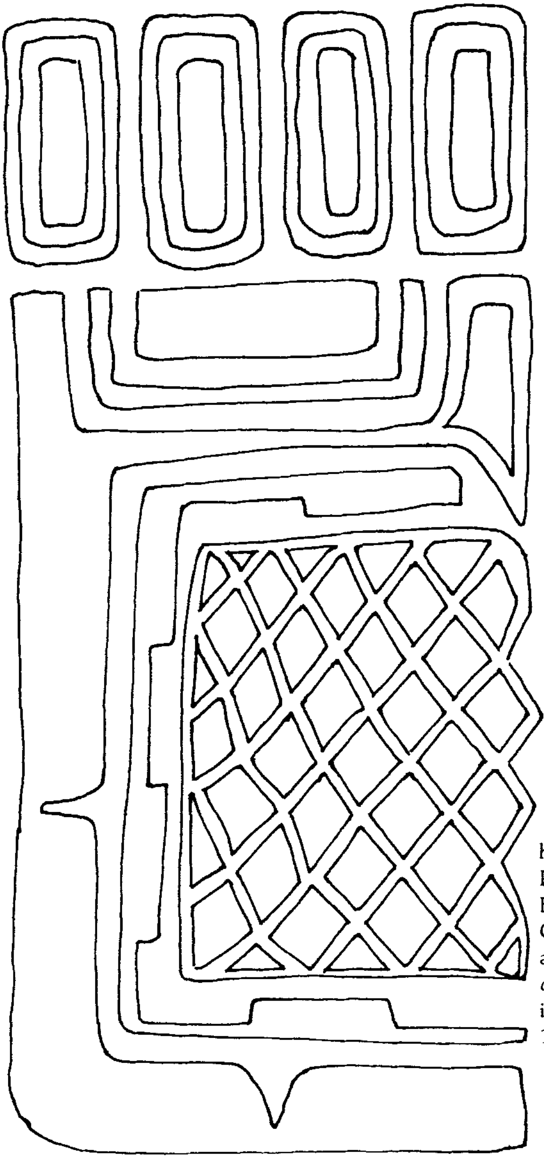

FIGURE 14. Earth monster head with net or mat in mouth. Relief on a clay roller stamp, Las Bocas, Puebla. Olmec. Pre-Classic period. Drawing by the author after C.T.E. GAY, *Chalcacingo* (Graz, Austria: Akademische Druck und Verlagsanstalt, 1971), fig. 12.

profile head of the Olmec earth god on a roller stamp from Las Bocas has a huge mat or net in its open mouth (FIGURE 14). It is significant, therefore, that the modern Maya, like old Guatemalan dictionaries, usually refer to the entrance or doorway as the "mouth of the house."[130] Nothing could more logically be conceived as a suitable vehicle of passage through the opening in the universe than the door that was woven to exactly fit it. A door suspended by cords can indeed usually be pushed open in either direction.

THE FOLDS OF THE UNIVERSE

In the end, however, the infinite strands of the universe must have been seen as integrated into a giant pile of cloth. The Maya manuscripts are full of references to the "folds of the katun,"[133] and the Tizimin passage quoted at the beginning of this paper alludes to the underworld when it speaks of "the folds of death."[1] Nezahualpilli testified to the existence of the concept among the Aztec when, in his address to Moctezuma Xocoyotzin, he spoke of "the nine folds of the heavens."[134] Roys thinks that the Maya expression refers to the folds of the screenfold codex in which katuns were presumably recorded,[135] but the sharp angles created by codex folds are extremely uncommon in Mesoamerican depictions of folded objects. More commonly, such objects are presented with essentially rounded corners created by their reversals of direction (FIGURE 15). The undulant, meandering path that they trace is essentially that actually followed by the eye when reading the Mixteca-Pueblan codices. Such soft folds are far more suggestive of cloth than of paper, and the Tizimin reference to the "folds of death" as babies' swaddling clothes further indicates that the cosmos was perceived as a giant piece or pile of folded fabric (FIGURE 16).[1] Since it is more than likely that the Mesoamericans constructed their pyramids as symbols of both real mountains and the cosmos,[3] it is significant that the Aztec called the pyramid a *cue*, a word that translates as "skirt."

Maya katuns, moreover, are frequently described as arranged in a bundle; as the Chilam Balam of Tizimin tells us: "When the bundle of the katun shall be completely filled, they will tie it up."[136] In Classic Maya art, bundles are clearly wrapped with cloth, as opposed to paper, and are often composed of at least one stackfolded piece of cloth.[137] These bundles constituted important offerings, to judge from Maya vase paintings, and, in some cases, seem to have been treated like cult objects (FIGURE 17). We know that cotton blankets were the major form of cur-

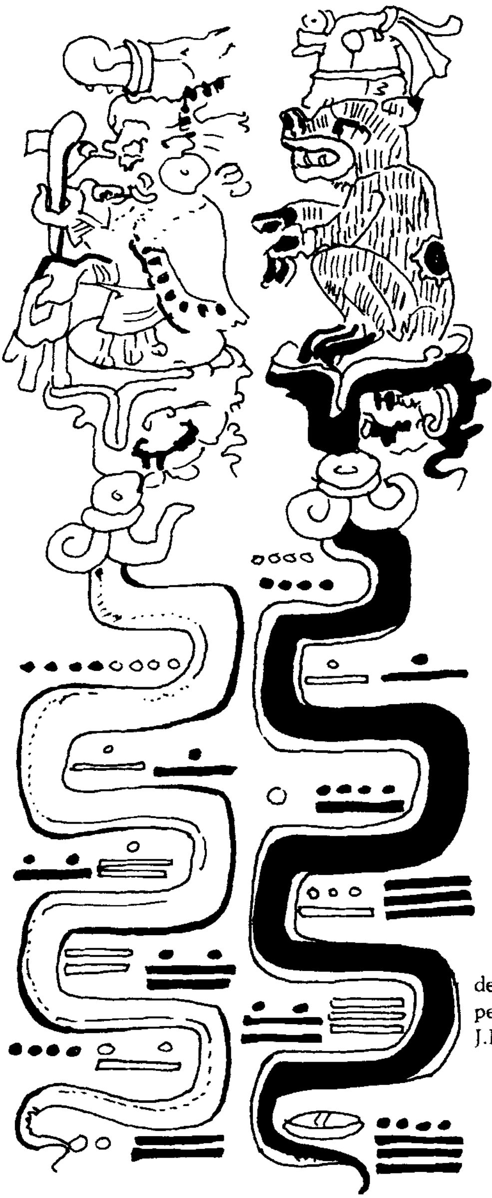

FIGURE 15. Undulant serpent, Codex Dresden, pl. 62. Maya. Post-Classic period. Drawing by the author after J.E.S. THOMPSON,[31] pl. 62.

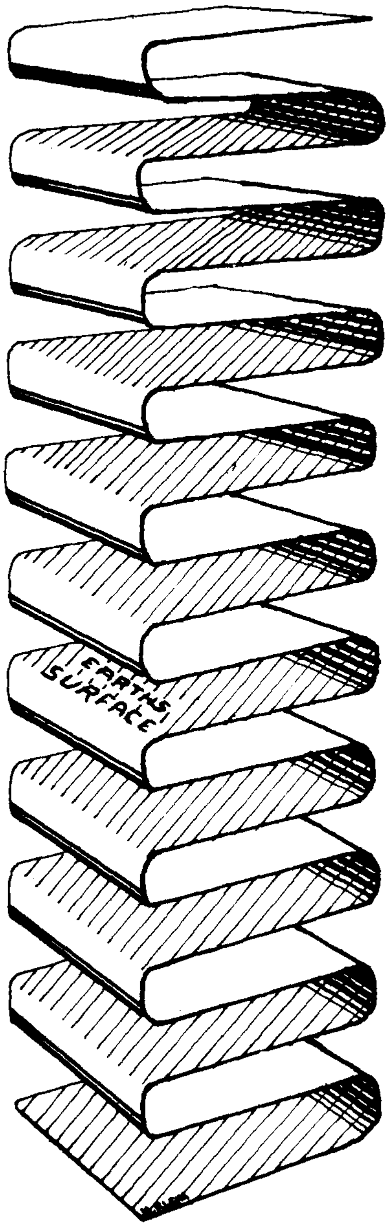

FIGURE 16. The Mesoamerican universe as a folded cloth: a model. Drawing by Henry F. Klein.

FIGURE 17. A bundle of folded cloth as a cult object. Detail of a scene on a Maya vase. Provenance unknown. Painted clay. Classic period. Dumbarton Oaks Collection. From F. ROBICSEK,[127] fig. 166, by permission of the author.

rency among the Aztec, and that they were used as the standard of value for other goods as well. In terms of preciousness, they outranked even cacao and gold dust.[138] One famous Aztec bundle reported by Torquemada contained animal skins identified as the "mantles of dead gods."[139] The report recalls the Kwakiutl tendency to equate animal skins with woven blankets, which they, too, valued above all other material goods. The name or reputation of a wealthy Kwakiutl chief was described as "heavy," a reference to the pile of blankets distributed to him at potlatch. The Kwakiutl referred to this important power symbol as "this mountain of blankets" that "rises through our heavens"; Irving Goldman sees it as a symbolic link with the sky.[140] Benson has uncovered evidence

that the Classic Maya rulers of Palenque, like certain deities, sat on thrones "that look like tied piles of blankets."[141] Given the demonstrated association of Maya thrones with the mat, the sun, and the *axis mundi*, it is noteworthy that Benson sees here an interchangeability of cloth and throne.

THE LOOM OF LIFE

That at least some Mesoamericans conceived of their universe in terms of cords and fabric should not really surprise us, given the importance of weaving in their daily life. Aztec girls were taught to use the loom from early childhood, and their most important manual task was the production of cloth.[142] The entire life cycle could be visualized in terms of various forms of twisted and netted, or woven, objects. Today, the Huichol infant is suspended from the rafters in a netted cradle;[143] in ancient times the Aztec bride and groom formalized their marriage by tying together the edges of their garments in a special knot.[144] The Aztec dead were wrapped with cloth and bound with cords prior to cremation,[145] while the Lacandon today lower their wooden caskets into the grave with twisted ropes.[146] Wauchope's description of the interiors of typical Yucatec houses today includes reference to an impressive variety of woven objects: baskets, henequen sacks and drawstrings bags, wicker and coiled liana trays, hammocks, mosquito nets, mat screens and wall hangings, plaited blankets, and, in Guatemala, floor mats and net storage bags as well.[147] Many of these furnishings, as in the past, are suspended from the rafters for protection. The house itself, as noted earlier, was and is virtually lashed and woven together. Agriculture, construction, and long-distance transport, moreover, were largely accomplished by means of woven containers, tumplines, and carrying cords.

For the rulers and nobility of the major city and empire-building states, a model of the universe as a huge pyramid of stone would have been vested with a reality and personal importance of the greatest magnitude. For members of the majority of Mesoamerican societies, however, as for the majority of all Mesoamerican people at all times, a masonry cosmos would have held little meaning. For these people the world has always been composed, not of stones, but of threads and fibers. For them, life has always been structured, contained, and bettered by the strands and folds of the spinner and weaver.

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Pyramid and Sacred Mountain

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RIMMED BY MOUNTAIN RANGES and snowcapped volcanic peaks, the Valley of Mexico is a spacious upland basin where urban agricultural communities were well established by the beginning of the first millennium A.D. The abundant natural resources and ecological variety of this basin and the surrounding territory had attracted migrant peoples since remote times. The first city of the valley to dominate the region was Teotihuacán, a powerful agricultural, manufacturing, and religious center with trade routes to all important areas of the Mesoamerican sphere. But with its collapse in the seventh century the fortunes of the Valley peoples ebbed, and it was not until the 1420s that the warlike rise of Tenochtitlan and her allies, Texcoco and Tlacopan, restored the old remembered hegemony. These independent confederated city-states built military empires reaching far beyond the Valley's natural borders, and their lists of tributary cities were still growing when the expedition of Hernán Cortés arrived in 1519.

Throughout the long and varied history of the valley, day-to-day subsistence and the most basic aspects of trade and tribute were always fundamentally dependent upon agriculture and the natural bounty of the land. For the population of the highlands the problem of maintaining a fruitful relationship between society and nature was central to their livelihood, and reached beyond economics to form the spiritual and intellectual underpinning of their culture. Elaborate architectural and sculptural settings were designed to express this relationship in visual symbols and to act as stages and memorials for seasonal rites and other ceremonies vital to rightful life in the community. During the past three decades, archaeological investigations have disclosed a complex network of connections linking ecology and agriculture to cultural evolution in ancient Mexico. It has been shown that increasingly efficient methods of raising crops and exploiting natural resources led to greater populations,

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permanent changes in the physical environment, and the formation of cities with complex social structures and specialized organizations. But the determining influences of Indian thought and symbolism in processes of cultural change is less well understood, and must certainly be accounted for in the schema of evolving civilization. How did the major forms of state-sponsored art reflect relationships between the physical and social worlds? How did these ordered architectural and sculptural settings contribute towards the cultural cohesion that is so vital to newly-established states in times of rapid and intensive change?

I will explore these questions by explaining the form and symbolism of two of the principal religious and civic monuments of Tenochtitlan and Texcoco. The first is the Main Pyramid of Tenochtitlan – a man-made urban artifact, the commanding shrine of the imperial Mexica capital (FIGURE 1). The second is the Sacred Hill of Tetzcotzingo, a natural elevation – embellished with architecture and sculpture – that overlooks the agricultural heartland of the kingdom of Acolhuacan about six kilometers from the capital, Texcoco (FIGURE 6). From the top of Tetzcotzingo the visitor may also see the distant modern towers of downtown Mexico City – Tenochtitlan – across the now-dry lakebed in the middle of the basin. Both the pyramid and the Sacred Hill were highly visible and centrally positioned, and they were closely tied to imperial authority during a century of dynamic military expansion and cultural change in the Valley of Mexico. Although different in appearance and setting, comparison of these two fifteenth century ritual places reveals that they were planned according to a similar iconic format and that they share a common unifying theme. An account of their main features will show that the pyramid and Sacred Hill were both designed to represent, in microcosm, the ecological components of the surrounding Valley; and that they were also places where the heroic deeds of legendary founding fathers were represented and remembered by their people. By comparing the two complex monuments it will be possible to see the form of a widespread Indian explanation of the world, how the religious integration of community and land was symbolically established, and why the memory of deified ancestral warriors and kings was fused with the imagery of landscape. The ideas represented by these monuments, and the covenants that were made upon them, gave coherence and religious meaning to the territory and the economic and political life of their respective nations.

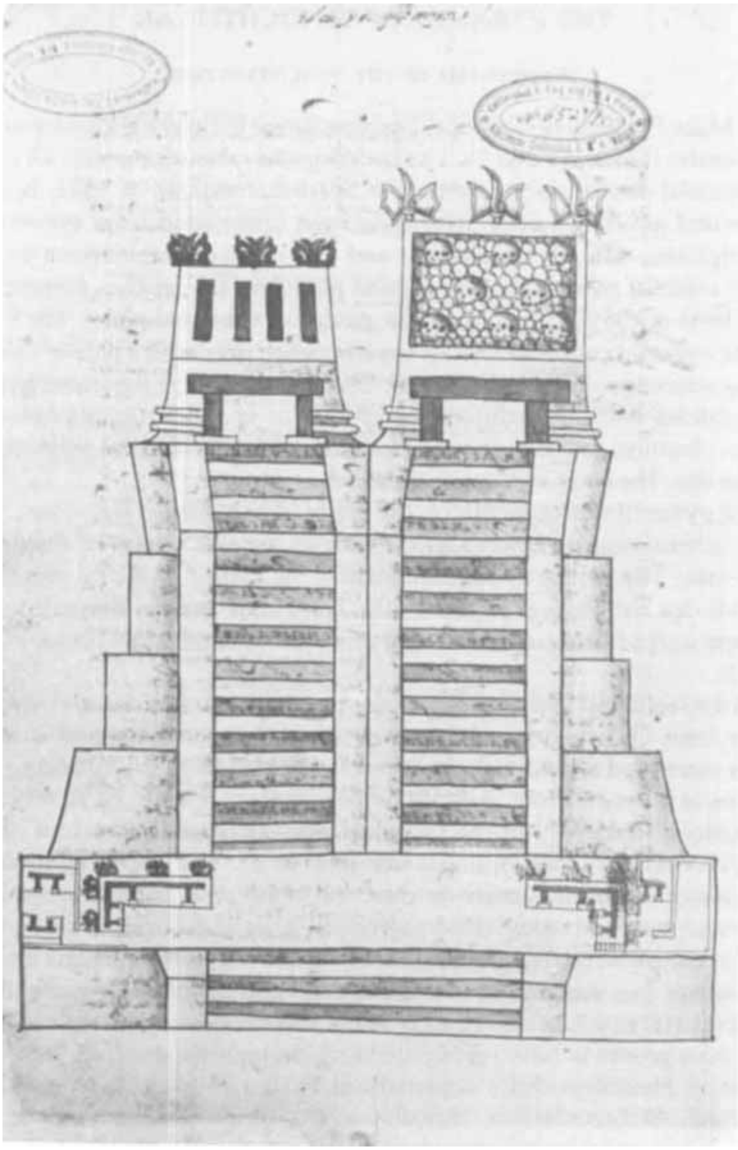

FIGURE 1. The Main Pyramid of Tenochtitlan. From the Codex Ixtlilxochitl, facsimile edited by Ferdinand Anders (Graz: Akademische Druck und Verlagsanstalt, 1976), p. 112v.

THE PYRAMID OF TENOCHTITLAN

THE PROBLEM OF THE DUAL STRUCTURE

The Main Pyramid of Tenochtitlan rose above the great enclosure at the city center (FIGURES 1 and 2). The building was razed along with all other ceremonial structures following the Spanish conquest of 1521, but its form and general position have long been understood from eyewitness descriptions, official documents, and manuscript illuminations of the early colonial period. Below, a broad platform, the *apetlac*, formed the first level of the pyramid above the paving of the ritual plaza. The body of the pyramid consisted of four superimposed tiers with a pair of steeply rising stairways on the west facade. The stairways were separated by flat balustrades with an architectural groove or channel running between them—features that have turned up in recent archaeological excavations at the site. The emphatic division almost certainly indicates that the body of the pyramid was conceived as the union of two distinct structures. The dual schema was completed by the pair of temples on top of the upper platform. The temple of Huitzilopochtli, the deified ancestral patron of the Mexica nation, was to the south. The Tlaloc temple, devoted to the ancient agricultural cult of rain and other forms of moisture, stood to the north.

Archaeological explorations of the pyramid foundations and vicinity have been undertaken since the beginning of the century and colonial texts were used to establish the extent and position of the building.[1] But the most extraordinary revelations began appearing in 1978, with the sensational discovery of the Coyolxauhqui sculpture at the foot of the stairway on the Huitzilopochtli side (FIGURE 3). The discovery soon led to a major excavation under the direction of Eduardo Matos Moctezuma. The sculpture and many other votive offerings and works of art embedded in the pyramid foundations have now led Matos Moctezuma and his colleagues to a reappraisal of the buildings and its meaning in the life of the imperial city.[2] As will be seen below, the south side of the dual structure now proves to have represented a mythological mountain, the magic scene of Huitzilopochtli's supernatural birth and triumph over Coyolxauhqui. At Tenochtitlan, Huitzilopochtli's shrine was the religious goal of homecoming Mexica armies and the place of triumphant sacrifices in honor of the deified ancestral patron. This information now opens the way for a detailed consideration of the Tláloc side. Although the agricultural and water aspects of this antique cult are well known, its nexus with the north side of the pyramid is not readily apparent. In the

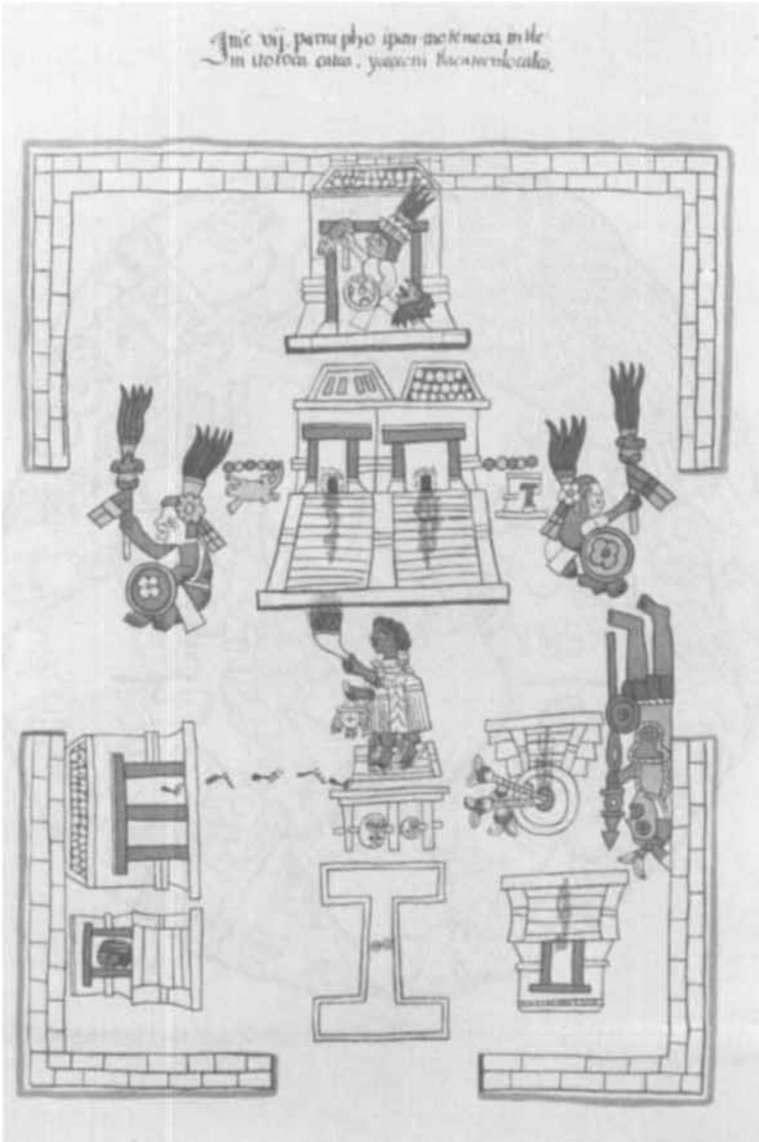

FIGURE 2. The Main Pyramid and the Ritual Enclosure of Tenochtitlan. After Sahagún, "Primeros Memoriales," Códice Matritense del Real Palacio (facsimile edited by Francisco Paso y Troncosco, Madrid, n.d.) v.

FIGURE 3. Coyolxauhqui, discovered at the stairway landing of the Huitzilopochtli side. Drawing by the author.

following discussion, I will show that the structure represents another kind of mountain—one related to, but distinct from, Huitzilopochtli's mountain home. The origin and meaning of this second architectural mountain, and the reason for its fusion with that of the ancestral hero, will be clearly seen in comparison with the Sacred Hill of Tetzcotzingo. At Tetzcotzingo, natural geographic features were translated into architectural and sculptural imagery and connected to memorials of a dynastic king. It is a place where an old, often-remarked, but never fully explained relationship between the design of Mesoamerican religious places and the forms of landscape can be understood.

ASTRONOMICAL CONSIDERATIONS

A review of the astronomical orientation and functions of the pyramid will help to establish the ground for interpretations. Anthony Aveni and Sharon Gibbs have clarified the astronomical connection by showing that a drawing of the pyramid from Cortés' Tenochtitlan map of 1525 and a quotation from Fray Toribio de Benavente describe the position of the structure in relation to the equinoctial position of the sun.[3] Cortes' cartographer depicted the exotic shapes of Indian architecture in European terms by representing the twin temples as a pair of towers reached by outside stairways (FIGURE 4). The map also mistakenly placed the pyramid on the west side of the ceremonial enclosure, but an indication of its true orientation was given by the small face drawn between the towers. It is quite likely that this face was meant to represent the sun, for Toribio de Benavente (Motolinia) identified the orientation of the structure in relation to the sun in his account of the springtime festival of Tlacaxipehualixtli: "This festival takes place when the sun stood in the middle of Huichilobos, which was at the equinox, and because it was a little out of straight Moctezuma wished to pull it down and set it right" ("Huichilobos" was Huitzilopochtli, whose name was applied to the entire pyramid by Benavente). Aveni and Gibbs calculated that the south wall of the pyramid stood at 7°6′ south of east and that the sun would have indeed been seen to rise between the dual temples on the equinoctial day. The complex Tlacaxipehualixtli festival centered on planting and regeneration rites, which were combined with military ceremonies in which young Mexica warriors were confirmed in their profession. At Tenochtitlan, as elsewhere in the valley, analogies and parallels were automatically drawn between events in the cosmic cycle and events in the sphere of society. The pyramid of Tenochtitlan was thus a pivotal

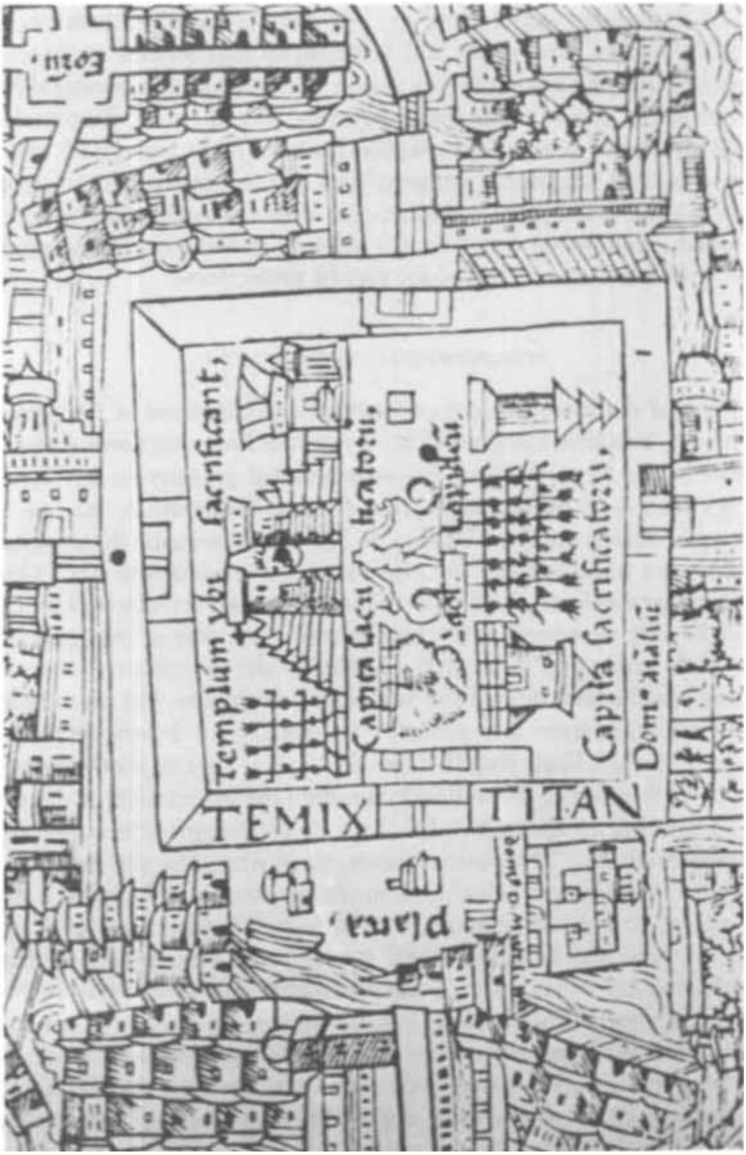

FIGURE 4. Detail from Cortés' map of Tenochtitlan, showing the Ritual Enclosure and the twin-towered pyramid. Note the sun-face between the towers. From Artes de México, número 49/50, Año 11, January, 1964.

building in the Mexica world, a material reference point linking a key day in the passage of the seasons to the physical space of the city and its agricultural and military life.

HUITZILOPOCHTLI'S MOUNTAIN

The Huitzilopochtli temple enshrined an effigy of the deified Mexica hero, who was also represented by costumed impersonators on ceremonial occasions. These performers wore an emblematic hummingbird headdress, which represented *huitzilihuitl* "hummingbird," part of Huitzilopochtli's name. The performers also carried shields and darts to signify the hero's role as guardian of the nation and patron of the warriors par excellence. The imagery of Huitzilopochtli's mountain-pyramid has been clarified by the newly discovered Coyolxauhqui sculpture buried in the landing of the south stairway (FIGURE 3). The sculptural relief is carved upon a slightly irregular disc-shaped monolith averaging about two and a half meters in diameter. Coyolxauhqui is depicted as a dismembered female with limbs displayed in a dynamic swastika-like pose—surely the most violent and fearsome image in the Mexica sculptural repertoire.

Coyolxauhqui, the body of the pyramid, and the Huitzilopochtli temple were thematically linked to represent a setting and a central mythological event of the Mexica nation. The myth recounts events from a time before the migrant tribe had reached their destination in the Valley of Mexico. The place was Coatepetl, or Coatepec, "Serpent Mountain," home of a guardian priestess named Coatlicue (the name Coatlicue, "Serpent Skirt," was also a metaphor for the sacred earth). Coatlicue was the mother of Coyolxauhqui and a great number of others, the Centzonuitznaua. One day, as the priestess Coatlicue was sweeping the earth-shrine at the mountain she was magically impregnated by a ball of feathers from the sky. This was the supernatural conception of Huitzilopochtli. Coyolxauhqui and her siblings were outraged, and gathered in a host to storm the hill and kill their dishonored mother. But a traitor to their cause ran ahead and informed Huitzilopochtli, still within the womb, of the impending assault. Huitzilopochtli suddenly sprang forth, armed as a mighty warrior, and devastated his enemy. Coyolxauhqui was cut to pieces and tumbled down the mountain-side.[4]

Matos Moctezuma notes that this tale was probably a way of recounting actual events of Mexica history, such as a dispute of tribal factions during the migration times.[5] In commemoration of the event, the Tenochtitlan pyramid was named Coatepetl, forever defended by the

deified Huitzilopochtli. By placing the fearsome Coyolxauhqui sculpture at the landing leading to his shrine, a powerful message was spelled out to ambitious Mexica warriors and their enemies alike. When triumphant Mexica armies returned to Tenochtitlan with captives to be sacrificed in sign of the submission of new tributary towns, prisoners were led by Coyolxauhqui on their way to the block in front of Huitzilopochtli's temple. The sacrifices reenacted the mythic-historic battle on the mountaintop. The sacred nature of Huitzilopochtli's mountain was underlined at the conclusion of the bloody rites, as Mexica warriors circled the pyramid four times in ritual circumambulation. In reviewing the symbolic schema of the pyramid, Matos Moctezuma points out the systemic relationship between the myth, the rites, and the ascendant warrior ethos and tributary economics of Tenochtitlan. A final feature of Huitzilopochtli's temple is that it was also a royal reliquary. The Mexica kings formed special spiritual bonds with the deified ancestral patron and their ashes were buried in the pyramid beneath the stairway to the shrine. In this way, the structure was also a dynastic memorial, a monument to the kings who found their spiritual model in the legendary chieftain of an earlier, mythologic, tribal time.

THE PYRAMID OF TLÁLOC

The Tláloc cult was very old in the Valley of Mexico, appearing in the brightly painted murals of Teotihuacán with images of goggled masks, flowing water, and agricultural fertility. Such representations continued to form the core of this cult art, which assumed new force in the Mexica symbolic system. Tláloc's shrine atop the pyramid of Tenochtitlan was no less venerated than that of Huitzilopochtli, and it held an effigy said to have been filled with seeds of all the most important cultivated plants. Tláloc impersonators also appeared upon the pyramid and in the plazas of the city on festival occasions, and the illuminated codices depict them richly dressed in goggled masks, jade jewelry, crowns of heron feathers, and holding green cornstalks or wands representing lightning bolts in their hands (FIGURE 5). Fray Diego Durán tells us that Tláloc was the "God of rain and lightning, and thunderbolts and all kinds of storms,"[6] and Bernardino de Sahagún speaks of Tláloc's associations with fertility and maize.[7] Many finds in the pyramid foundations were dedicatory offerings of this cult, of which the most striking were large ritual water jars, polychromed and modeled with masks like those depicted in the codices. Other offerings show the close connection of Tlaloc's cult with that of Chalchihuitlicue, "She of the Jade Skirt," which was specifically

FIGURE 5. Tláloc, from the Codex Ixtlilxochitl, facsimile edited by Ferdinand Anders (Graz: Akademische Druck und Verlagsanstalt, 1976), p. 110v.

devoted to water on the ground—springs, lakes, and rivers. Among these objects were seashells, a splendid necklace of carved mother of pearl and a pendant frog of jade, miniature green stone model canoes complete with implements of fishing and bird-hunting, and myriads of tiny fish carved of lustrous shell. The offerings illustrate the bonds between the pyramid and the professional food-producing groups of the Mexica capital and lake environment.

These many finds now bring us to the still-unanswered question about the significance of the side of the pyramid supporting the Tláloc temple. If the south side was an architectural mountain, a replica of Huitzilopochtli's mythic-historic battleground, what was the meaning of the north side of the dual structure? A starting-point to find the answer is presented by the etymology of Tláloc. Thelma Sullivan has pointed out that the name should actually be spelled Tlalloc, which, translated, can be said to mean "he who has the quality of earth," "he who is made of earth," or "he who is the embodiment of earth."[8] Since cult names metaphorically describe the nature of the cult, why should rain and other forms of moisture be primarily identified in terms of earth? Part of the answer lies in textual sources, as Sullivan has noted. The Histoire du Mechique recounts a cosmological myth that describes the earth as follows. Tlaltecuhtli, "Lord Earth," or "Lady Earth," was the source of all life: her hair was the source of trees, flowers, and plants; from her skin and tiny hairs came the smaller plants and flowers; her numerous eyes (she was said to have eyes and mouths at the limb joints) were springs and fountains and small caves; her mouths were caverns from which rivers issued; and her nose formed valleys and mountains. This cosmic image thus associates the interior of the earth with water. The description leads us to look directly at the mountainous environment of the highlands: in the rainy season, mists are seen to rise from deep ravines, and clouds condense upon high mountaintops before sweeping down to water the waiting agricultural fields. In the dry season, springs and small creeks continue to supply the needs of settlements and cities. It is no wonder that the Indians of this region customarily spoke of mountains as being filled with water. Thus, the cosmological image of this myth illustrated phenomena that could be seen and experienced in the physical environment. With this in mind, it is therefore possible to see that the Tláloc side of the pyramid at Tenochtitlan represented a cosmic mountain of sustenance, the symbolic source of life and agricultural prosperity for the people of the city.

This interpretation can now be confirmed by comparing the imagery of the pyramid with the Sacred Hill of Tetzcotzingo. A comparison of the two

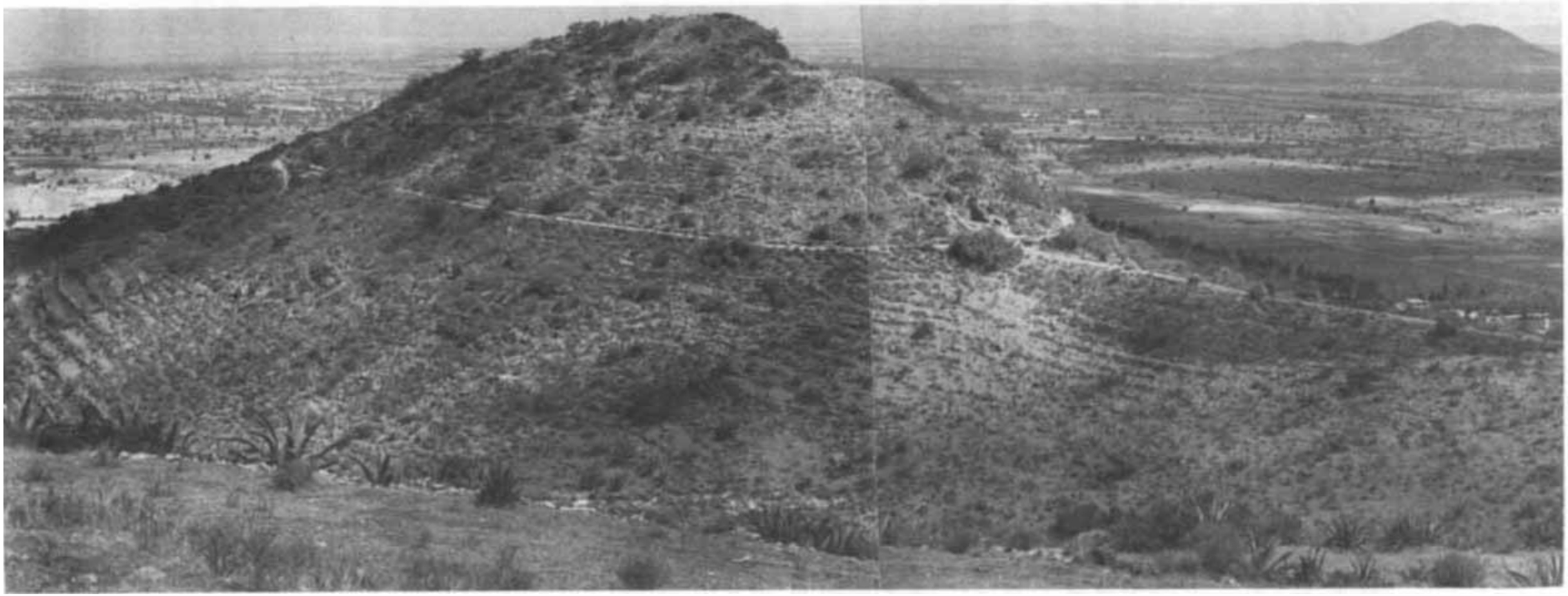

FIGURE 6. The Sacred Hill of Tetzcotzingo.

civic and religious places will not only show variant forms of the mountain of sustenance, but will also illustrate similar ways of fusing the memory of founding fathers and dynastic kings to that topographic symbol.

THE SACRED HILL OF TETZCOTZINGO

The hilltop ritual place overlooks the agricultural heart of the kingdom of Acolhuacan, with the capital, Texcoco, in the distance (FIGURES 6, 7). The summit lies about 208 meters above the level of the plain. During the 1450s, the hill was equipped with architecture and sculpture by king Netzahualcoyotl of Texcoco (FIGURE 8). At the same time, extensive farming terraces were under construction in the surrounding landscape and aqueducts were built to supply numerous towns and villages throughout the area. I first visited Tetzcotzingo in 1978 and returned to map the ruins during the summer of 1979.[9] I will summarize certain aspects of this information with facts about the plan of the site and an examination of one of Netzahualcoyotl's personal monuments. Although necessarily abbreviated, the facts reveal a basic underlying affinity between Tetzcotzingo and the pyramid of Tenochtitlan. To be consistent with the discussion of the pyramid, I will begin with an outline of the plan and orientation of Tetzcotzingo and then proceed to Netzahualcoyotl's monument and a review of the imagery of landscape. All the architecture and sculpture at Tetzcotzingo was severely damaged by the Spanish ecclesiastical authorities in 1539, but texts, illuminated manuscripts, and related works of art provide enough information to decode the remaining fragments.

COSMIC PLAN AND ORIENTATION

The plan shows how the upper section of the hill was organized, with a system of cult stations or shrines arranged in a cosmological design (FIGURE 7). The ritual area is demarcated by a walkway cut completely around the hill, at a level of 55 meters below the summit. The remnants of baths or basins are still seen upon the path at points corresponding to the cardinal directions (FIGURE 7[A]). They were supplied by aqueduct from springs high on Mt. Tlaloc, to the east of Tetzcotzingo. The path and bathing-places served the purposes of religious circumambulation and purification. It was a widespread custom among the Indians to designate a hallowed area by circular or rectangular processions, and the path at Tetzcotzingo was designed to signal that the hill was sacred.

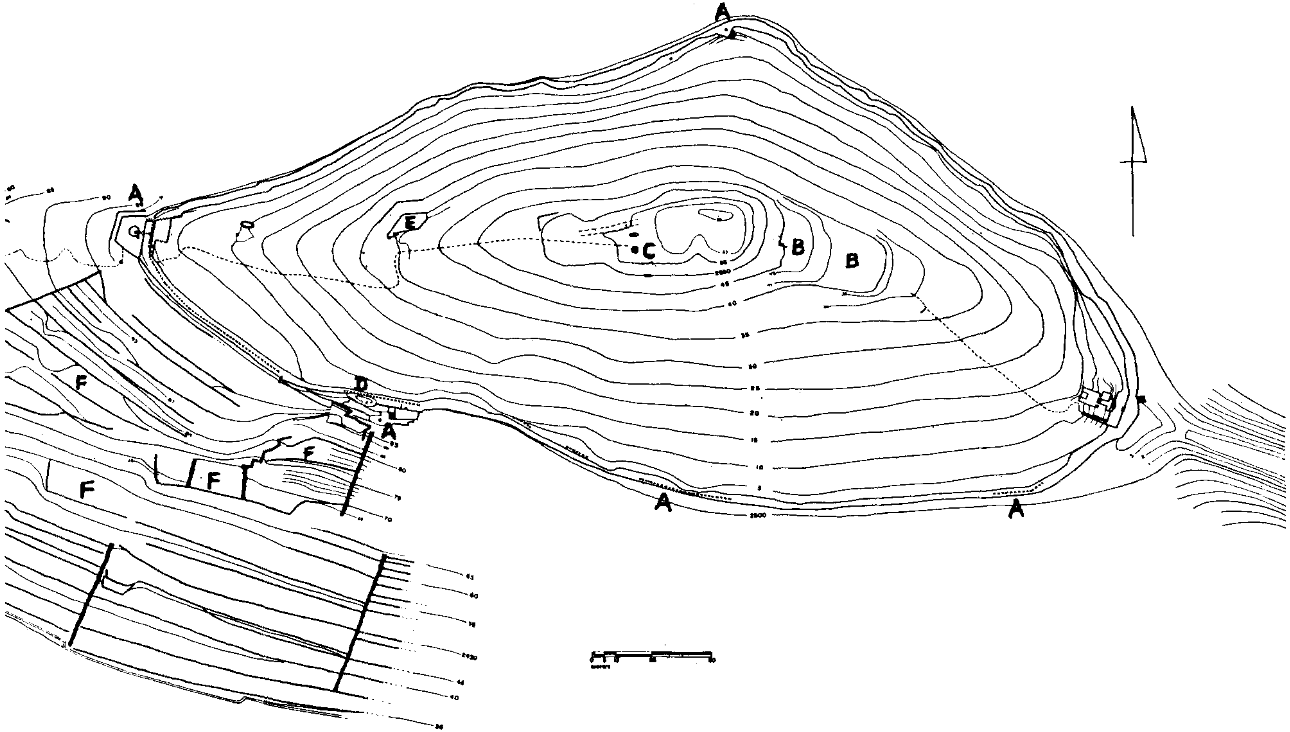

FIGURE 7. Map of the ceremonial area of Tetzcotzingo. Surveyed and prepared by the author and Matthew Pietryka. (A) Aqueducts and baths, (B) Assembly plaza and Netzahualcoyotl's monuments, (C) Tláloc mask, (D) Cave, (E) Earth and New Corn Cult Effigies, (F) Probable location of Netzahualcoyotl's villa and botanical plantations; — retaining wall, —— boundary wall, - - - - ancient aqueduct, ═ functioning aqueduct, --- footpath, – rock cut, ▥ steps, o rock-cut basin, ~ edge of walk.

FIGURE 8. Netzahualcoyotl, King of Texcoco. From the Codex Ixtlilxochitl, *facsimile edited by* Ferdinand Anders *(*Graz: Akademische Druck und Verlagsanstalt, 1976), *p.* 106r.

Another sequence of stations were arranged along an east-west axis within the enclosed area, following the steep natural ridge-line of the hill. This arrangement echoes the passage of the sun, like the axial emphasis of the Tenochtitlan ritual enclosure. An architectural fragment below the summit shows an angle of 14° 24′ east of north, a measurement within the range of orientations published by Aveni and Gibbs for other highland ruins. This leads to the inference that Tetzcotzingo had astronomical functions akin to those of the Tenochtitlan pyramid, as a place where religious and state events were coordinated to the seasonal cycle at equinoctial times.

NETZAHUALCOYOTL'S MONUMENT

A spacious assembly-plaza was constructed below the summit by artificially leveling the eastern shoulder of the hill. Standing on this platform looking west, the viewer faces an elevated stage with a badly damaged architectural backdrop embedded in the bedrock of the mountain (FIGURES 7[B] and 9). The hollow seen at stage center was blasted by treasure-hunters in colonial times, who completed the havoc first wreaked in 1539. It may be that this was the place of a biographical sculpture of Netzahualcoyotl mentioned in an extensive description of Tetzcotzingo by Fernando de Alva Ixtlilxochitl.[10] But this complex monument demands extensive research before it can be conclusively discussed. A more immediately promising relic of the original sculptural program can still be seen to the left of the damaged central monument (FIGURE 10). At first glance, the upright rounded stone seems to be an eccentrically eroded boulder, but the form can be linked to reliable texts and shown to have been a hieroglyphic effigy of the Texcocan monarch. The most important text is the Titles of Tetzcotzingo, a sixteenth-century legal document recording Netzahualcoyotl's original fifteenth-century will of water rights. The original document (prepared at Tetzcotzingo) assigns water rights to the magnates of surrounding towns; it concludes with a description of a royal effigy by way of affixing an imperial seal on the transaction:

> And on the side of the hill called Tetzcotzingo
> there they drew his picture
> as his face was;
> and beside it on the stone something like a *quetzalquetlachtli*
> his artificers drew, or sculptured, by order of Netzahualcoyotzin
> whereby he was represented
> so that there they should see it
> his children, his grandchildren, and everybody.[11]

FIGURE 9. The assembly-plaza and site of Netzahualcoyotl's historical memorials at the top of Tetzcotzingo. The cave-like opening at center was blasted out by treasure-hunters in the colonial period; it may have been the place of a biographical relief similar to the one described by Ixtlilxochitl in the early seventeenth century. To the left, an upright boulder is all that remains of the kings' animal-effigy.

FIGURE 10. The remains of Netzahualcoyotl's animal-effigy, described as a plumed wolf or coyote in the Titles of Tetzcotzingo. It was decapitated and all sculptured surfaces chipped away in 1539. The curve of the seated hind leg and paw may still be distinguished at lower center, and an upright foreleg in front.

The description tells us that the king's likeness was qualified by hieroglyphic elements. *Quetzalquetlachtli* is a compound word formed of *quetzal*, the precious bird whose long green iridescent feathers were reserved for royal headdresses, and *quetlachtli*, a species of Mexican wolf. In a metaphoric sense, the word *quetlachtli* was used to say that someone was a valiant and intrepid man. The king's image was thus represented as a feathered wolf – a figure similar to the small sculpture of a coyote in the National Museum of Anthropology in Mexico City (FIGURE 11). The effigy at Tetzcotzingo is now reduced to a rounded knob of stone, barely showing the residual shape of an upright seated animal; the head is gone and the sculptured surface of the body was chipped away, but it is still possible to distinguish the curve of the animal's rear leg and the long straight forelegs in front. The effigy was also referred to by Fray Francisco Dávila Padilla, who climbed around the ruins of Tetzcotzingo in the 1580s.[12]

The sculpture was already in its present condition at that time, and Padilla seems not to have actually found its physical remains. But he was informed of the existence of a famous statue, which he called "Zaualcoittl," known to have represented a "great fasting Indian . . . said to be a saint" and held in great esteem by the Indians of the region. Curiously, Padilla did not know of Netzahualcoyotl's historical identity, but his "Zaualcoittl" can be no other than the monarch, whose name means "Fasting Coyote." Padilla knew of the Indian tendency to deify their most beloved kings and heroes, and he remarked on the custom in his account of the Tetzcotzingo ruins. Finally, Fernando de Alva Ixtlilxochitl also mentions the royal effigy, noting that the figure faced towards the east.[13] At once a three-dimensional hieroglyph and a metaphor for the king's valiant warrior role, the image confronted the assembled magnates of the kingdom on the parade-ground immediately below. The sculpture was commissioned by the monarch to remind the population of his historical achievement in the early fifteenth-century wars that established Texcocan independence and built an empire in alliance with Tenochtitlan, and of his later patronage of hydraulic works and other agricultural projects that helped ensure the economic stability of Acolhuacan.[14]

His personal memorial was an integral part of the Sacred Hill, seen against the landscape where those historical events had taken place. It faces the direction of the rising sun, and thus unified the memory of the triumphant happenings that marked the beginning of imperial Texcoco with the daily appearance of the sun and the renewal of the seasons.

FIGURE 11. Mexica seated coyote. Photograph courtesy of the Museo Nacional de Antropologia, Mexico.

FIGURE 12. The Tláloc mask at the summit of Tetzcotzingo.

Although Netzahualcoyotl was a historical person, he was enshrined in the memory of his people in the form of a religious cult: in this respect, he occupied a place at Tetzcotzingo that was analogous to that of Huitzilopochtli at Tenochtitlan.

THE IMAGERY OF LANDSCAPE

Netzahualcoyotl's monument occupied a high position on the hill, and the hill itself was a great natural icon designed to mirror the most important ecological features of the valley. The essential aspects of the plan can now be identified (FIGURE 7). The summit of the site shows only a few traces of foundations and rubble from the buildings that once crowned the ceremonial area. The colonial texts are silent on the nature of these buildings, but a goggled Tláloc mask engraved on a bedrock boulder shows that at least one of them was dedicated to that ancient cult (FIGURES 7 [C] and 12). The grafitto-like quality of the scored image suggests that it had been a dedicatory identifying mark, an ex-voto in the foundations of a now-demolished building. The Codex Borbonicus depicts Tláloc temples on the tops of mountains, and there were several of these shrines in the heights around the valley (FIGURE 13).

Below the summit, the border of the ceremonial area was defined by the circumambulation path, which also supported water-channels and bathing-places at the cardinal points (FIGURE 7 [A]). The waterworks, supplied by springs high in the Mt. Tlaloc range to the east, fulfilled purifying purposes; and running water was itself addressed as Chalchihuitlicue, "She of the Jade Skirt," in ceremonies honoring that element among the valley peoples. Other natural shrines at Tetzcotzingo include a cave, at the transition-point between Netzahualcoyotl's residence and botanical plantations on the lower south slope of the hill, and the circumambulation path above (FIGURE 7 [D]). The religious function of caves as places of communion with *tepe yiollo*, "mountain heart," or *tlalli yiollo*, "earth heart," both metaphors for the earth's life-generating powers, is well documented in the recent literature; their social functions in rites of passage,[15] including those of royal coronation, has been described in specific terms at other Mexica cave-temple sites.[16]

The last important station to be mentioned is placed high upon the east-west axis, with a view of the cultivated fields stretching towards Texcoco and the lakeshore (FIGURE 7[E]). This shrine is still occupied by the fragments of two sculptured effigies that can be identified as Tlazolteotl-Cinteotl types of nature-deities, representing the firstfruits of

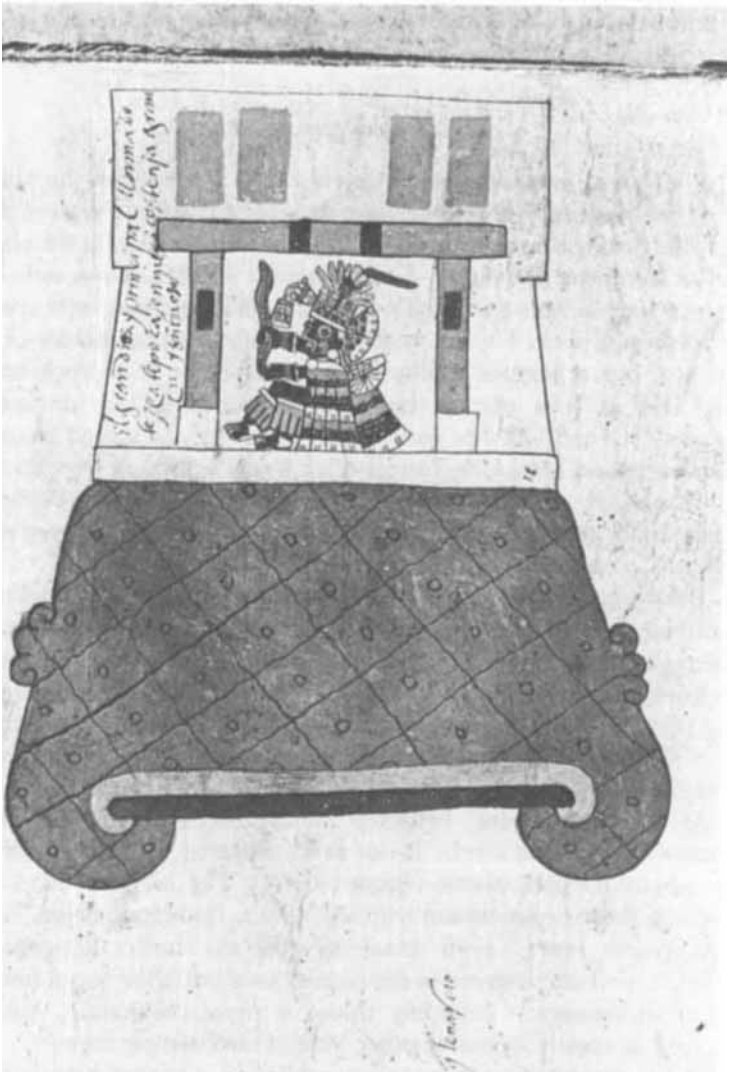

FIGURE 13. A Tláloc temple on a mountaintop. From the Codex Borbonicus, facsimile with commentary by Karl Anton Nowotny and Jacqueline Durand-Forest (Graz: Akademische Druck und Verlagsanstalt, 1974), p. 25.

the agricultural season. At Tetzcotzingo, these and other shrines form part of the mountain, manifesting an aspect of the hill or the surrounding countryside that was especially significant. At these connected shrines the kings and magnates performed rites that linked their people to the sacred forces of the earth and sky that gave them life. Tetzcotzingo repeats, in microcosm, the agriculturally meaningful components of the valley: rainclouds form on high peaks during the summer season, there are springs and flowing streams below, after which follow agricultural terraces and piedmont fields leading to the lake at the center of the basin.

This same configuration was repeated in architectural form by the Tlaloc side of the Tenochtitlan pyramid and by the sculptures and votive offerings recovered from its foundations. As at Tetzcotzingo, this Mexica pyramid-microcosm functioned as a universally recognized metaphor, a symbolic mountain of sustenance to which the warlike signs of the deified national hero and the memory of dynastic kings were attached. Tetzcotzingo occupied a central position in the landscape of Acolhuacan, visible from Texcoco and the other most important towns. In like manner, the Pyramid of Tenochtitlan was the central beacon of the island-city. At both places, the military and agricultural professions were connected through religious means to symbols of the natural elements upon which life depended. These natural elements and symbols were those of a sacred mountain, the meeting-ground of earth and sky. The mountain monuments were places where the integration of polity and physical environment was ritually established, where the memory of kings was consecrated, and where mythical or historical models for the ethos of warlike nations was expressed. Constructed in the century that saw imperial power rapidly expand from the Valley of Mexico to other regions, these complex symbolic settings fulfilled a vital socially integrating role in the religious, economic, and political life of their communities. In these respects they asserted the internal stability and cultural cohesion sought by the ambitious rulers of the allied city-states.

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Precision in the Layout of Maya Architecture*

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WE TEND TO REGARD attention to detail and exactitude in craftsmanship among the defining characteristics associated with the artistic achievements of the advanced civilizations of the world. The more organized a society becomes, the greater seems its need to collect, classify, synthesize, and refine information. Thus, the degree of precision and complexity of any ancient astronomy is usually found to be commensurate with the level of sophistication of the economy, urban planning, and architecture of the society that practices it.

At first glance, the great civilizations of Mesoamerica seem no exception to this rule. The Maya, heralded as outstanding mathematicians and astronomers by virtue of the written documents they have left us, also erected great cities. But their monumental remains provide us with a discordant contrast when we begin to look at them in detail.

Why was it that the architects of so precise a calendar as the Venus Table in the Dresden Codex[1] so badly misaligned the walls of many of their buildings? Unlike the Teotihuacanos of Central Mexico, who typified pristine precision in the design and execution of the grid of their great city and ceremonial center,[2] the people of the Petén who built Tikal oriented the walls of the five great temples at angles ranging from 7° to 18° from true north.[3] Little wonder that Thompson concluded that

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"variation arises from sloppiness. . . . Divergence of one wall from another presumably resulted from the inability of the Maya to lay out right angles."[4] But surely any culture capable of creating the Copan Hieroglyphic Stairway, Temple IV of Tikal, or the Temple of the Inscriptions at Palenque also must have possessed the capacity to execute a simple 90° corner in stone, a feat demonstrably quite elementary (see Appendix). Perhaps the Maya didn't care; maybe they had symmetrophobia.[5] Or was misalignment deliberate, with precise right angles and perfectly parallel walls sought only in certain special cases?

Recent studies of building alignments demonstrate that astronomical events were often a consideration in the location, layout, and specific orientation of certain components of Maya cities and ceremonial centers.[6] But pure geometrical motives have been given little attention. Moreover, no one has examined either the degree of precision in the parallelism and rectangularity of the ground plans of monumental structures or possible methods the Maya might have used to lay out the buildings—both related problems. To begin this inquiry, we shall test Thompson's statement taken as a question: Were the Maya able to erect right angles?

Because we cannot use extant archaeological site maps to solve our problem (they are not accurate enough),[7] we are forced to go to the field, employing a surveyor's transit with an astronomical fix[8] to derive the absolute orientations of the walls of Maya buildings. Given the devastation and neglect associated with most Maya remains since the Spanish intrusion, we are immediately confronted with the problem of establishing a sufficient data base. Indeed, a long period of examination of the bases and corners of many structures at a large number of sites needed to be undertaken before the process of measurement began. As our final set, we have chosen only those structures which remain in good condition, altered as little as possible by both the hand of the excavator and subsidence and contortion through time. These include structures in the northern part of the Yucatán Peninsula at the Puuc-Maya site of Uxmal dating from about A.D. 800 and at the ruins of Chichén Itzá (A.D. 900–1000). Also, we have selected portions of four structures that lie in relatively good original condition at the ruins of Palenque in the southwest portion of the Yucatán Peninsula (ca. A.D. 700). For comparison, we used a set of modern Western architectural structures. We measured walls of structures on the campus of Colgate University, Hamilton, N.Y.[9] and determined the angles formed at their corners. These buildings, some erected as early as the beginning of the 19th century and some as recently as the late 1970s, might be expected to provide

TABLE 1

SUMMARY OF GEOMETRICAL DATA ON WALL ORIENTATION AND THE ANGLES AT CORNERS OF BUILDINGS

Ancient Sample			Average Deviation of Corners from Right Angles	Deviation from Parallel	
Site	Building	Epoch		Long Walls	Short Walls
Uxmal	Governor's Palace	A.D. 800	3°35′	< p.e.	1°14′
	House of Turtles	A.D. 800	0°24′	0°20′	0°11′
	Nunnery–North Building	A.D. 800	0°52′	< p.e.	1°44′
Chichén Itzá	Akab D'zib	A.D. 900?	1°01′	0°12′	2°03′
	El Castillo	A.D. 1000	0°23′	< p.e.* to 0°33′	
Palenque	Palace House E	A.D. 700?	1°12′	0°24′	< p.e.
	Palace House B	A.D. 700?	3°09′	0°23′	5°07′
	Temple of the Sun	A.D. 700?	2°35′	–	2°29′
	Temple of the Foliated Cross	A.D. 700?	2°00′	–	0°32′
Unweighted Average for Ancient Buildings			1°41′	0°15′	1°41′
Contemporary Sample					
Colgate University	West Hall	A.D. 1819	0°32′	0°38′	0°16′
	East Hall	A.D. 1850	0°20′	< p.e.	–
	Alumni Hall	A.D. 1859	< p.e.	< p.e.	0°16′
	Lathrop Hall	A.D. 1905	0°10′	–	–
	Hascall Hall	A.D. 1906	0°07′	< p.e.*	
	Memorial Chapel	A.D. 1916	0°35′	–	–
	Lawrence Hall	A.D. 1926	0°15′	–	0°21′
	McGregory Hall	A.D. 1930	0°10′	–	–
	Olin Hall	A.D. 1970	0°20′	< p.e.	1°02′
	Wynn Hall	A.D. 1979	< p.e.	–	< p.e.
Unweighted Average for Modern Buildings			0°16′	0°12′	0°22′

* Walls are of equal length

us with some indication of the amount of alteration in rectangularity of the ground plan of a building through time. Furthermore, such measurements might also offer us some information on how well the ground plans of our own buildings conform to perfect rectangles.

Of course, the Maya buildings that we chose to study are far older and, therefore, more subject to the ravages of time, than the post-Conquest test set of buildings. Given all the aforementioned limitations, we proceed to look at the mass of data derived in the field and assembled in TABLE 1.

PRECISION IN THE GROUND PLAN OF INDIVIDUAL BUILDINGS

For the suggestion that we measure the Governor's Palace at Uxmal (FIGURE 1a) we are indebted to J. Kowalski. While undertaking his study of the iconography of that building,[10] he pointed out to us that he found it strange that the corners of the structure seemed to deviate noticeably from the perfect right angles. Kowalski had made some preliminary measurements with a T-square and protractor and he wondered whether more exact measurements would corroborate the apparent inconsistency he had discovered between precise astronomy and imprecise geometry. Curiously, our data reveal both a "yes" and a "no" answer to the question. As Kowalski's estimates suggested and FIGURE 1b shows, the building plan is more a parallelogram than a rectangle; the corners deviate from 90° by about 3½° on the average. The relatively short (north and south) walls are out of parallel by 1¼° but the east and west walls, about 100 m in length, lie within our error of measurement (6 minutes of arc probable error or "p.e." in the table) of being perfectly parallel. From astronomical evidence discussed in Note 11, we note that these are the very walls the Maya would have had reason to align with precision.

Our measurements on the neighboring House of the Turtles[12] (dimensions 10.5 m north-south and 29.0 m east-west) and the more distant North Building of Uxmal's Nunnery (dimensions 8.5 m north-south and 75.0 m east-west), two buildings that do not seem to possess a known astronomical function, also reveal that the long walls are precisely parallel. In fact, in the former case, the building corners approximate the right angle as closely as most buildings (see TABLE 1 for the comparative data). Unfortunately, none of the other buildings comprising the Nunnery has more than one or two original measureable walls intact. But the Akab D'zib at Chichén Itzá does; it dates from approximately the

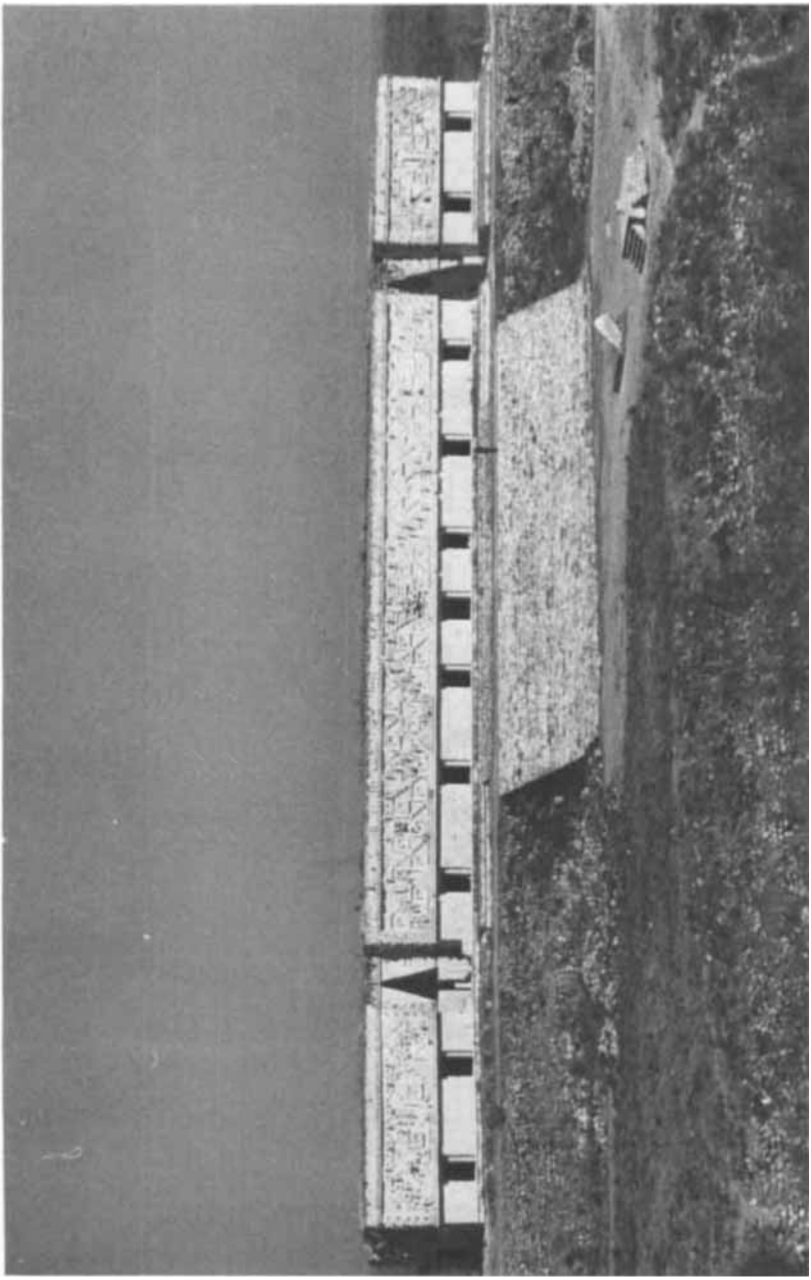

FIGURE 1a. The Palace of the Governor at Uxmal – façade viewed from the east.

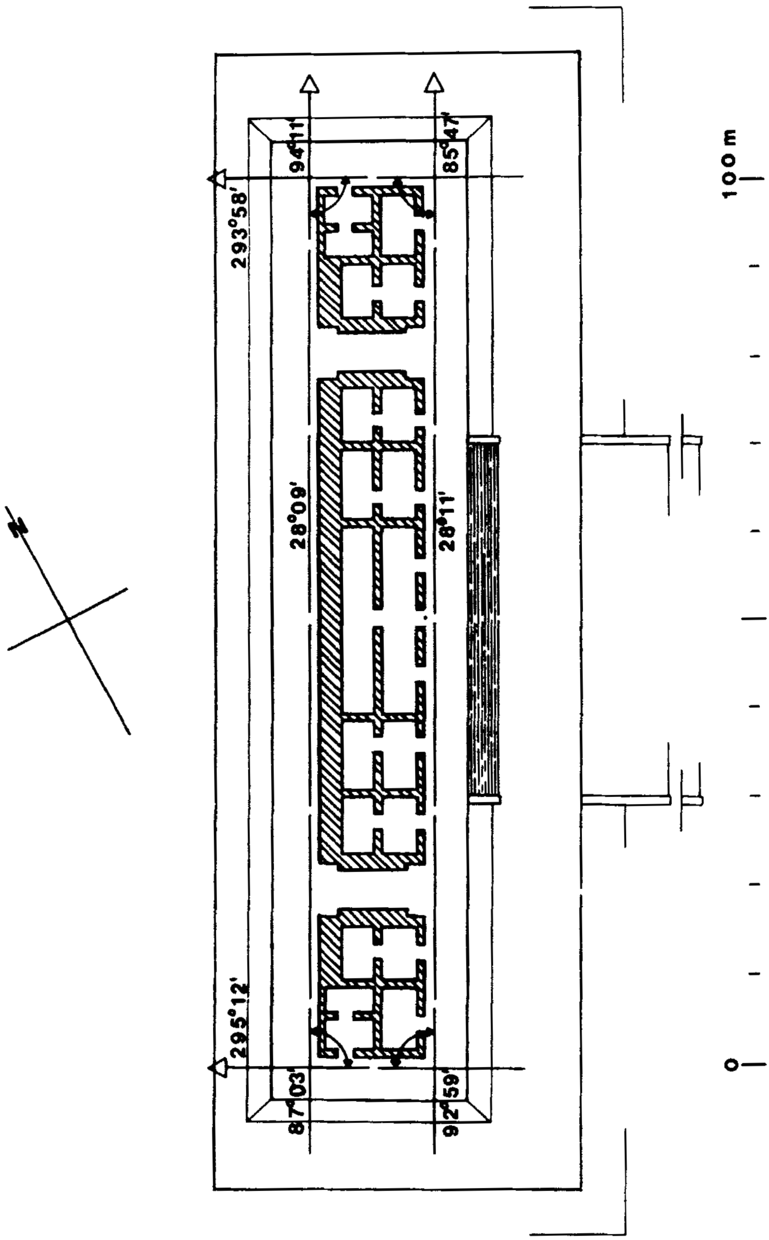

FIGURE 1b. Schematic ground plan of the Place of the Governor at Uxmal.

same epoch and it reveals the same pattern. (The dimensions of the building are 53.0 m north-south by 15.0 m east-west). While the corners deviate an average of 1° from 90° (the southwest corner forms an 89° angle) the long east and west façades are misaligned by only 12′.

Moving to the Castillo, a building from a slightly later period, we find, once again, one set of opposing walls more closely parallel than the other two; however, in this case, all sides are of the same length. At Palenque we measured portions of four buildings: Palace Houses B and E, the Temples of the Sun and the Temple of the Foliated Cross. The corners of none of them averaged better than 1° from a right angle, but the long walls that yielded a reliable measurement averaged 2° closer to parallel than the short walls, deviating on the average less than ½° from parallel. For the entire set, the average deviation from parallel of all long walls was 15′, a little more than double the measurement tolerance, while short walls averaged 1¾° out of parallel, about 15 times the tolerance.[13]

Our modern test sample of buildings, erected on the campus of Colgate University a millenium after the Maya architects did their work, exhibits corners and walls that deviate from the ideal by about the same magnitude – 2 or 3 times the 6′ tolerance. The data scarcely hint at a chronological correlation, though the ground plan of Colgate's newest building, the Wynn Hall of Chemistry built in 1979, is as close to a rectangle as we can judge. Also, the oldest structure on the campus, erected 160 years earlier, makes a far better parallelogram than a rectangle. However, when university archivist Howard Williams informed us that the construction of the latter building was supervised by a Colgate professor, we began to suspect that more than the ravages of time might be laid to blame for the inaccurately turned corners exhibited by this building today. Relative to the ancient sample, the modern buildings possess more accurate right-angle corners and short walls are more nearly parallel; however, it is curious that long walls on both samples still stand with the same accuracy.

While the Maya buildings listed in TABLE 1 exhibit one or two accurately turned right angles that may be coincidental, our measurements suggest that, in conceiving and constructing their buildings, Maya architects were primarily concerned with erecting the front and back (long) walls precisely parallel. Presumably, this could have been accomplished with a cord of constant length very carefully drawn out by eye perpendicular to a given line. Closure of the structure by short walls appears to have been an afterthought.

In the case of the Governor's Palace, we wonder how the builders

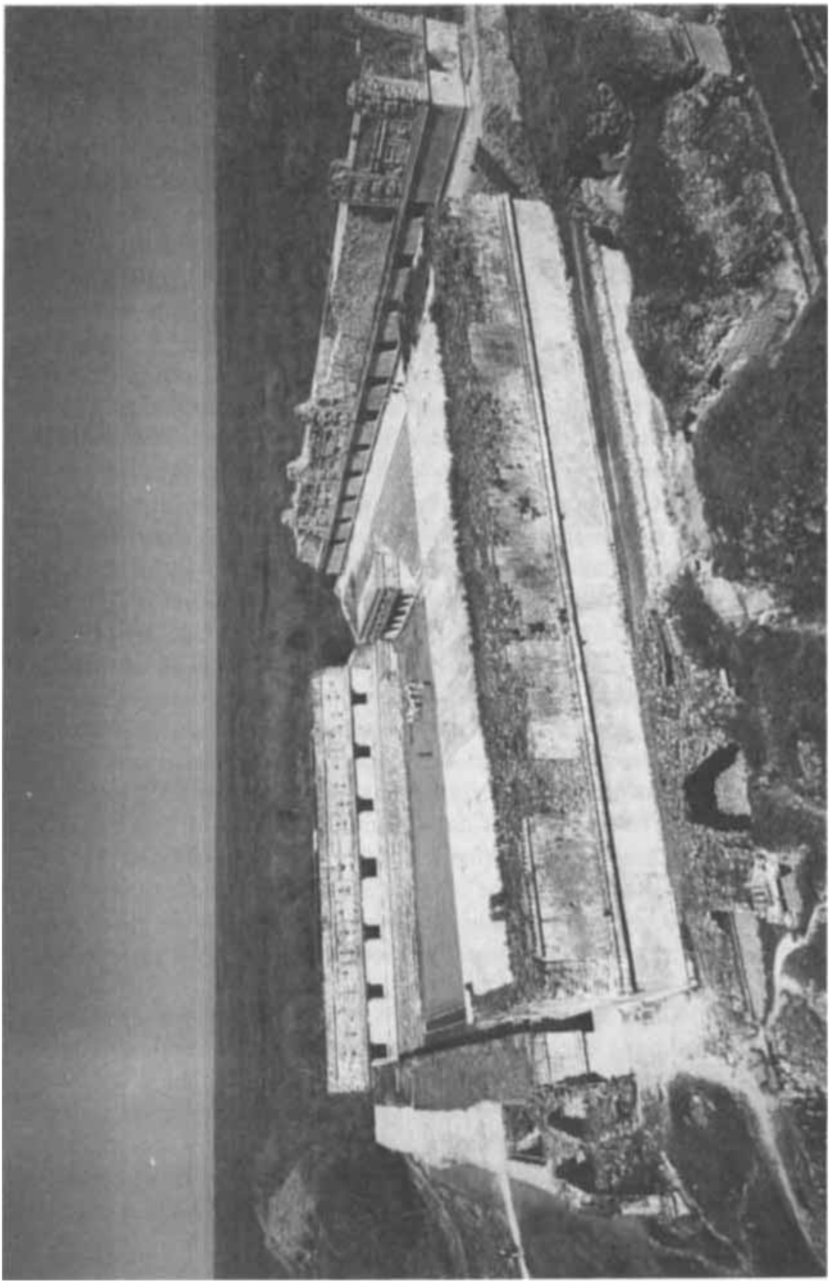

FIGURE 2a. The Nunnery at Uxmal. View from the east and above.

determined the line of the façade so that the perpendicular to the central doorway would align exactly with Nohpat and the southerly extreme rising point of the planet Venus. We have succeeded in proving what already might have been obvious on logical grounds; that the Maya architects did not accomplish this task by sighting along the short walls of the building and then constructing the long walls perpendicular to them. Rather, the builders must have erected the large artificial platform at Uxmal first. Then they laid out a sight line to Venus at its southerly extreme, perhaps using a series of sticks positioned by visual sightings of the planet at horizon as viewed from the intended location of the doorway of the Palace. Once the position of the central doorway of the Governor's Palace was incorporated into the plan it could be employed to determine precisely where to locate the Nohpat pyramid. Later, the portion of the baseline nearer Uxmal could be fixed with a cord, and then a perpendicular cord could be laid down to mark the alignment of the eastern (front) façade that was intended to overlook Nohpat. Finally, a parallel cord could be arranged to delimit the western (rear) façade of the Governor's Palace. In the absence of additional evidence about Maya construction technology and planning, it seems dangerous to push this already speculative scenario much further at this time.

PRECISE GEOMETRY IN INTER-BUILDING RELATIONSHIPS

The Nunnery complex of Uxmal serves as a useful example to demonstrate another way Maya architects were concerned with precision. Other examples also display a consideration of careful geometrical relationships involving different buildings at the same and at other sites. For want of space, we will discuss only the Nunnery in detail.

Why is the Nunnery (FIGURE 2a) such a paragon of asymmetry? Located in the northeast section of Uxmal adjacent to the Pyramid of the Magician, it is comprised of four rectangular buildings that enclose an irregular courtyard approximately 60 m by 80 m. But a look at the plan (FIGURE 2d) showing the relative placement of the four component structures reveals that sloppiness, even disregard of detail, could hardly have resulted in the asymmetry and nonrectangularity at the junctures of the four major buildings that we observe today (the angles are 84°49′ SW, 92°43′ NW, 94°12′ NE, and 88°16′ SE). Indeed, the four buildings appear so out of line that they force us once again to entertain the notion that misalignment was deliberate.

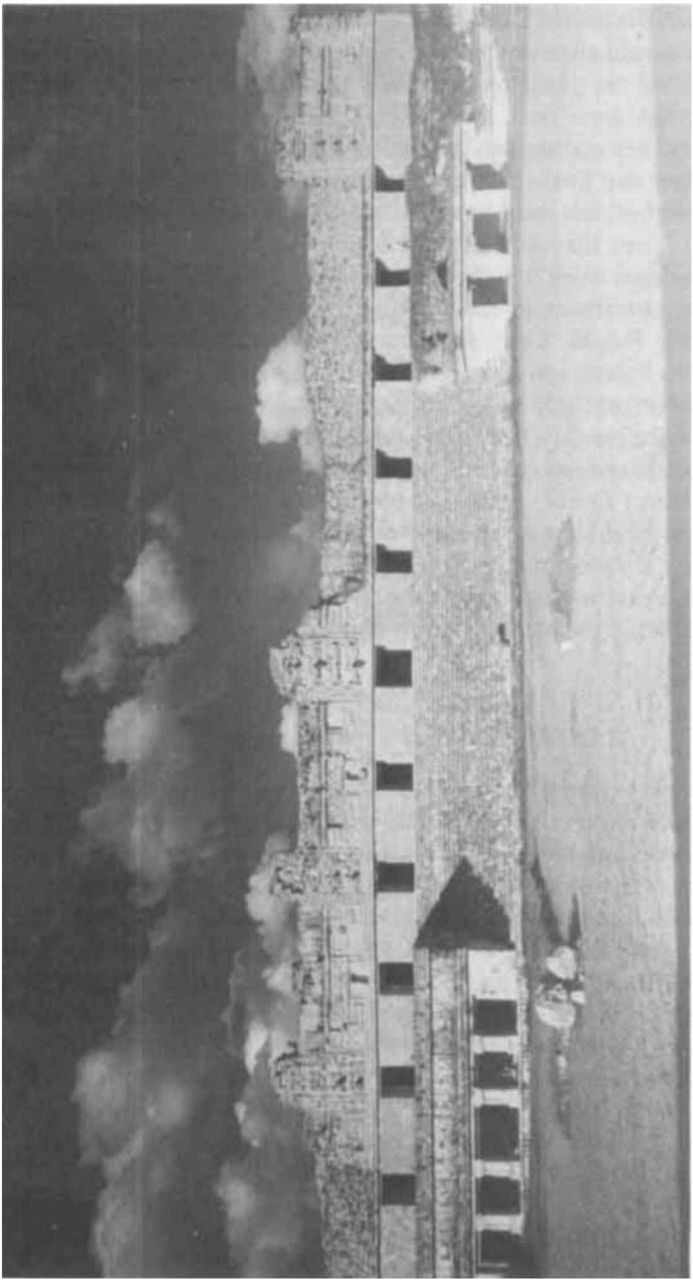

FIGURE 2b. The North Building of the Nunnery as viewed from the archway of the South Building.

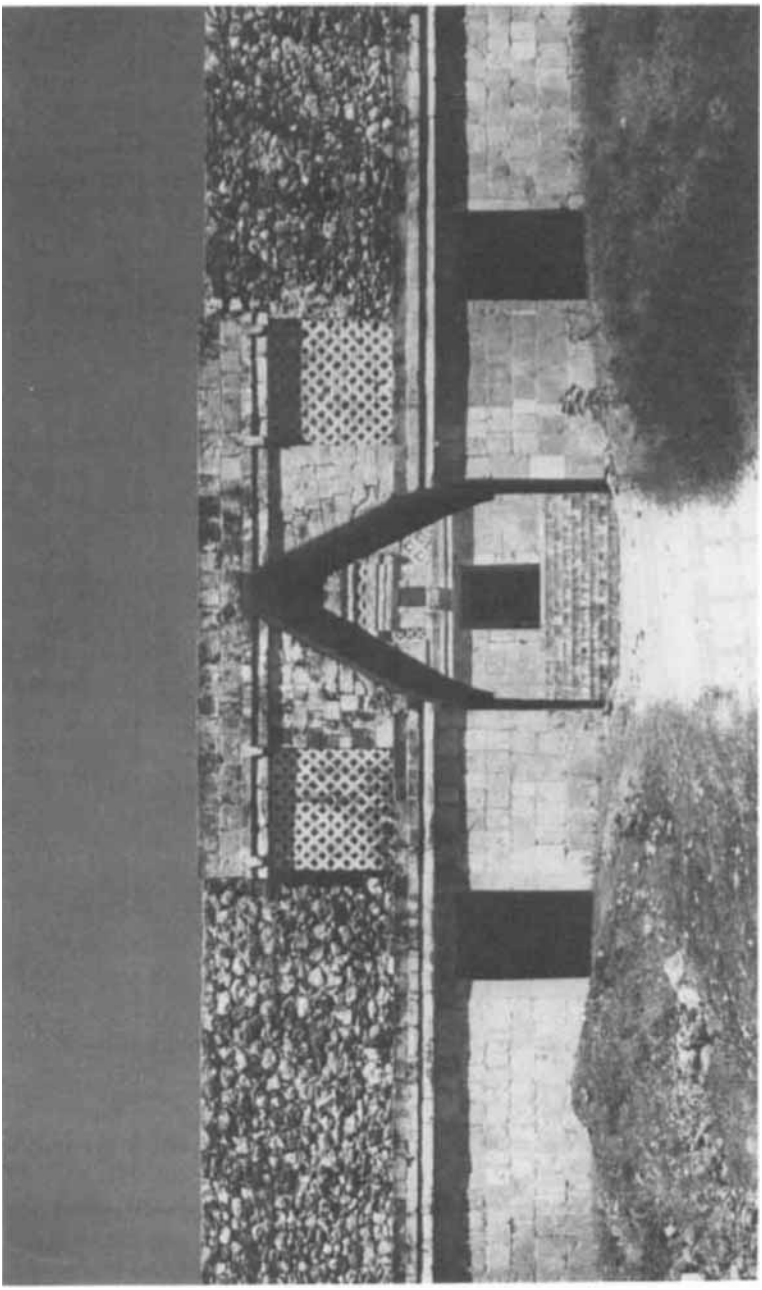

FIGURE 2c. View through the archway of the South Building of the Nunnery. The doorway to the left of the central doorway of the North Building is framed by the archway.

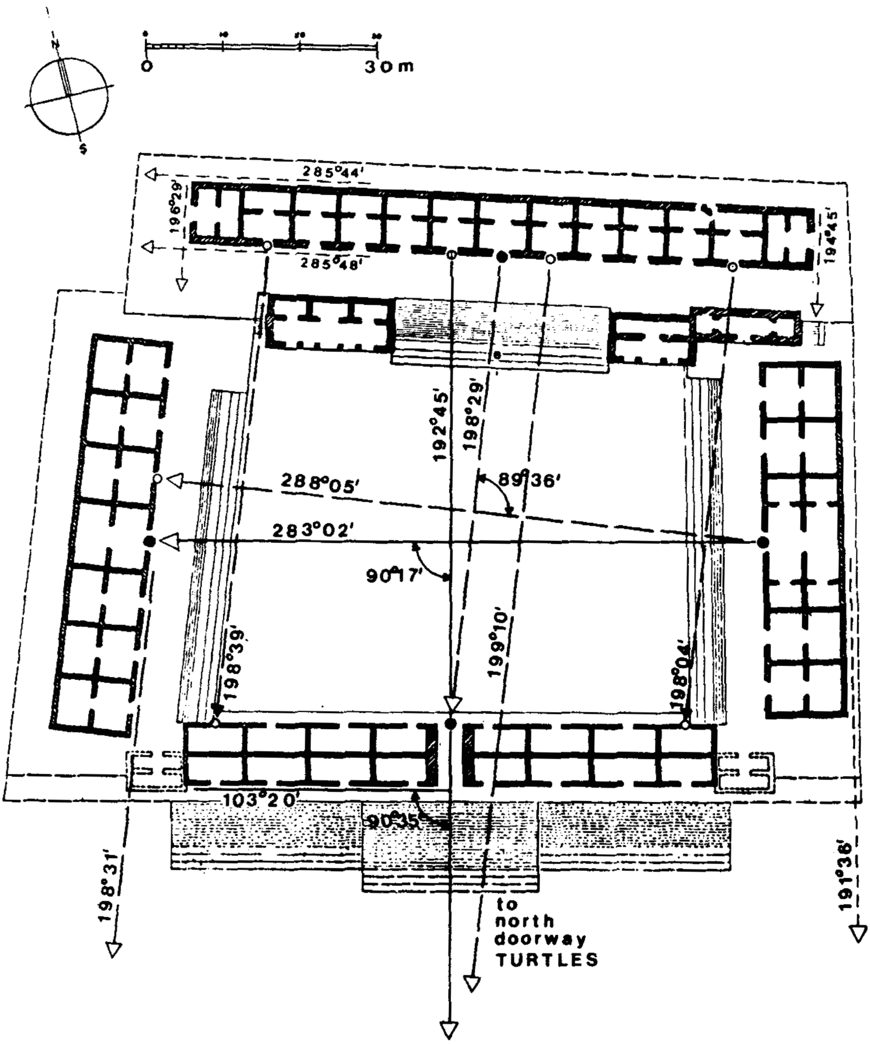

FIGURE 2d. Alignments relating component buildings in the Nunnery of Uxmal.

To begin with, some numerical oddities about the Nunnery are worth considering. Each structure opening on the court contains an odd number of doorways: 5 on the east building, 7 on the west, 9 on the south (counting the grand entrance archway), and 11 on the north.[14] Standing in the fifth doorway (counting from the west) of the North

Building one looks southward over the archway on a line to the Governor's Palace, a structure possessing 13 doorways on its eastern front (see FIGURE 1a). From the floor of the Nunnery courtyard one can sight the Governor's Palace framed in the archway.

Next, refer to FIGURE 2d and consider the following axes: (a) that formed by a pair of lines, one connecting the central doorways of the east and west structures, the other the central doorway (the archway) of the south structure and that doorway adjacent on the west to the central doorway of the north structure,[15] (solid lines in FIGURE 2d), and (b) that formed by another pair of lines, one connecting the central doorway of the north and south structures and the other connecting the central doorway of the eastern structure with that doorway adjacent on the north to the central doorway of the western structure (dotted lines in FIGURE 2d). These axes intersect at nearly right angles (90°17′ for a and 89°36′ for b) near the center of the patio. Moreover, the south and west buildings are made to dominate the other two because their facades possess an orientation that is parallel to one arm of the aforementioned axes. The west building is parallel to the north-south arm of axis b while the south building aligns with the east-west direction of axis a (the errors are 2′ and 18′, respectively). Finally, the extreme doorways on the north and south buildings lie along parallel lines (error 35′), a direction shared by (1) a line taken from the doorway adjacent on the east to the central doorway of the northern structure prolonged to the House of the Turtles and (2) the façade of the House of the Turtles itself.

The aforementioned observations involving both the double set of axes and the sets of parallel lines in the Nunnery complex illustrates a construction principle or a set of rules that is both precise and consistent, even if somewhat strange to us. The precise right angles we sought at the corners or junctions of buildings now appear in an abstract way in open space, at the center of the courtyard between the buildings. Of course, the process of discovery of the pair of right angles as we relate it can be very different from the manner in which the Maya conceived and planned the Nunnery. Like all works of art, it is seen and interpreted through the eyes of the beholder.

One can strengthen the case for geometrical planning by alluding to visual lines that connect with other structures at Uxmal. Indeed, we have already shown that, in the ground plan of the whole site, it is likely that the placement of certain buildings, in particular their doorways, were positioned according to both astronomical and "mega-geometrical" principles executed on a large scale.[16,17] Lacking any confident data about the

construction sequence of the Nunnery,[18] it seems unwise to speculate on the methodology for the entire layout.

Similar interbuilding relationships that may have been governed by geometrical considerations are found to occur at Tikal, Copán, and Chichén Itzá. Since the arguments have been published separately elsewhere, it may be useful only to summarize them here.

1. At Tikal we find a perfect right angle between the doorways of T-IV, T-I, and T-V and an isosceles triangle between T-I, T-III, and Str. 5D-104, the doorway of the last structure serving as apex (one leg of the triangle is a perfect east-west line).[19]

2. At Copán, another site where we find good evidence for astronomical alignments,[19,20] our measurements disclosed certain possibilities alluding to the use of the geometrical arc. Concentric arcs pivoted at the masonry block (or altar) in the upper part of the northern stairway of Temple II can be swung from (a) Altar O to Stela M, located at the base of the Hieroglyphic Stairway and (b) the center of the Ballcourt through the doorway of Temple 22 to the central marker of the East Court of the Acropolis. The latter is a perfect right angle.[21] Furthermore, the lines between Altar O and Stela M, and also between the masonry block and the doorway of Temple 22, are parallel to the transverse axis of the Ballcourt.

3. At Chichén Itzá, the Caracol, a Maya observatory, serves as the focal point for a curious geometrical arrangement. A single arc pivoted at the Caracol intersects the center of the Great Ballcourt, the center of the Venus platform, the thrones in the inner chambers of the Chacmool Temple and the Temple of the Warriors, and the center of the Ballcourt on the eastern side of the Court of the Thousand Columns. The angle between the imaginary lines from the Caracol to the aforementioned ballcourts is a radian.[20,24]

Still other examples of interbuilding references and relations have been recognized at Piedras Negras[22] and Yaxchilán.[23]

CONCLUSIONS

The evidence assembled in this paper seems insufficient to justify any elaborate conclusions about the extent to which geometry played a role in Maya city planning. Nevertheless, we believe we have provided some first steps to a solution of this problem. Until further data are gathered and analyzed, we suggest that the following working hypotheses be established in place of Thompson's position of 1974 and that they be con-

sidered as refinements of his rather simple and sweeping statement quoted at the outset:

1. While the Maya often were concerned about attaining true parallelism in the long walls of their facades, a task that we view as fully within their technological capabilities, they bothered less to fit the shorter side walls to complete their buildings with perfect right angles; however, on occasion they did attain an accuracy equivalent to that found in wall alignments of contemporary buildings. At least such accuracy can still be demonstrated today in spite of more than a millenium of decay and ruin in the Maya standing architecture.

2. Certain building complexes appear to be so misshappen and disoriented that deviations from symmetry surely must have been deliberate. When one of these complexes (the Nunnery at Uxmal) is analyzed in some detail, certain parallel and right angle relationships arise that are too numerous, precise, and consistent to be fortuitous. The possible interrelationship of a given building or complex to other architectural components at a given site suggests that grand planning involved astronomy as well as geometry. The details of such planning have not yet been worked out. Indeed, astronomical and geometrical determining factors, not all of them necessarily related, may have combined to influence the placement and orientation of a given architectural component.

3. The isosceles triangle, the radian, and multiple orthogonal axes may be listed among the geometrical concepts embodied in the architectural plans of Maya sites, as previous work at Uxmal, Tikal, Copán, and Chichén Itzá demonstrates.

We believe that a further study of precision and geometry in Maya architecture, subject to all the caveats listed in our introduction, now seems warranted. Apparently, the Maya will to impose human order upon the natural order of the environment via architecture proceeded in a planned fashion. Our conclusions, considered as detailed hypotheses, give us something definite to look for but they need to be refined further so that we can begin to look at the details of the process. First, larger masses of orientation data and precise measurements should be gathered so that we can proceed further with these arguments.

What relevance does our investigation bear to the theme of the conference? Our studies have shown that, like the ceque system and quipu of Cuzco, Peru, the arrangement of Barasana and Andean star patterns, or the iconography of the Aztec sun stone, architecture was another medium employed in the American tropics for the storage and transmission of precise knowledge. Thus, we should be motivated to look beyond

the written record as a measure of the mental capabilities and achievements of other cultures.

ACKNOWLEDGEMENTS

We thank P. Aveni and W. Underhill for their transit work on the Colgate buildings and W. Underhill for his experimental efforts at laying out right angles in the landscape and determining precision therein.

NOTES AND REFERENCES

1. J.E.S. Thompson, *A Commentary on the Dresden Codex: A Maya Hieroglyphic Book* (Philadelphia: American Philosophical Society, 1972).
2. When examined in greater detail, the fabled Teotihuacán precision also has its subtle asymmetries. While Millon *et al.*, *Urbanization at Teotihuacan* (Austin: University of Texas Press, 1973), stated that there is good evidence that the Teotihuacanos planned the grid structure of their city, still, these authors point out that "most long and many short east-west orientations are 91° or 91°30' east of Teotihuacan north." Moreover, most angles, including those at the corners of the Pyramid of the Sun and, especially, at the Ciudadela, deviate noticeably from a right angle (pp. 37, 53, 56, 57), the latter by a full order of magnitude greater than the building tolerance attributed to Teotihuacán builders by investigators on the mapping project. Without a doubt, the individual buildings were being forced to conform to nonorthogonal grids defined by several axes probably associated with different building epochs; e.g., 15°30' for the Street of the Dead, 106°30' for East Avenue, 106°55' for the Ciudadela, and 285°25' for West Avenue. There is good evidence that one of the underlying motives for setting up the peculiar, skewed, nonorthogonal Teotihuacán grid was astronomical. (J. Dow, "Astronomical Orientations at Teotihuacan: A Case Study in Astro-Archaeology," *American Antiquity*, vol. 32 (1967), pp. 326–334, and A.F. Aveni, and S.L. Gibbs, "On the Orientation of Pre-Columbian Buildings in Ancient Mexico," *American Antiquity*, vol. 41 (1976), pp. 510–517.)
3. A.M. Tozzer, "Prehistoric Ruins of Tikal, Guatemala," *Memoirs of the Peabody Museum*, vol. 5 (1911), no. 2.
4. J.E.S. Thompson, "Maya Astronomy," *Philosophical Transactions of the Royal Society of London, Series A*, vol. 276 (1974), pp. 83–98. The statement is on p. 94.
5. Atoni housebuilders of the Pacific always disoriented the doorways of their houses a few degrees from the east so as not to violate the sacred way of the sun (C. Cunningham, "Order in the Atoni house," in *Right and Left: Essays on Dual Symbolic Classification*, ed. R. Needham (Chicago: University of Chicago Press, 1973), pp. 204–238).
6. A.F. Aveni, *Skywatchers of Ancient Mexico* (Austin: University of Texas Press, 1980), chap. 5. For details see Hartung.[16,19,20]
7. A.F. Aveni, "Possible Astronomical Orientations in Ancient Mesoamerica," in *Archaeoastronomy in Pre-Columbian America*, ed. A. Aveni (Austin: University of Texas Press, 1975), pp. 163–190.
8. Details of the techniques are given in A.F. Aveni, "Archaeoastronomy," *Advances in Archeological Method and Theory*, vol. 4 (1981), pp. 25–32. Basically, we determined the absolute azimuths of walls or, in the absence of an astronomical reference, the relative orientation of one wall of a building with respect to another.

9. Multiple sets of measurements of all wall alignments were taken in order to establish estimates of probable error of measurement. Our greatest shortcoming in this regard lies not in transit reading accuracy, but rather in the fact that few original walls remain completely intact and perfectly straight.

10. J. KOWALSKI, (Diss. Yale University, n.d.) His work on the iconography of the Governor's Palace at Uxmal is in progress.

11. In an earlier investigation we had shown that the orientation of the Palace of the Governor is quite unusual.[7] Its façade is skewed 20° from the other buildings at Uxmal in a clockwise sense, as seen on a plan of the site. The main doorway seems to have been aligned deliberately (to within 8 minutes of arc) with the principal pyramid at the ruins of Nohpat 6 km distant. Also, the planet Venus at its extreme southerly rising point on the eastern horizon would have risen directly over the Nohpat pyramid (error 2 minutes of arc). Moreover, the façade of the Palace contains both Venus symbols like those appearing in the Venus table in the Dresden Codex and the number 8 written in dot-bar notation. This number may correspond either to the 8-year interval between identical Venus horizon extremes or to the 8-day disappearance of the planet before heliacal rise in the east.

12. This building also surmounts the artificial terrace of dimensions 153 m by 181 m occupied by the Palace of the Governor, the entire complex having been skewed 20° clockwise from the north relative to all the other buildings at Uxmal, presumably to align with Nohpat and Venus.

13. Our measurements on the Hall of Columns at Mitla, Oaxaca, one of the best-preserved non-Maya buildings in Mesoamerica (dating from about A.D. 1200), revealed no better overall building precision. Its corners deviated from a right angle by 0°53′ (avg.), with both short and long walls out of parallel by about the same magnitude.

14. See FIGURE 2b, where one can count the 11 doorways on the North Building as well as 3 and 5 doorways on a pair of buildings flanking the wide stairway leading up to it. The seven doorways of the west building can be seen in FIGURE 2a.

15. FIGURE 2c shows this alignment at ground level.

16. H. HARTUNG, *Die Zeremonialzentren der Maya* (Graz: Akademische Druck- und-Verlagsanstalt, 1971. See especially pp. 48–57, plan 6, and figs. 13–20.

17. A.F. AVENI,[7] pp. 182–187.

18. G. KUBLER, *The Art and Architecture of Ancient America* (Middlesex: Penguin, 1962), p. 149, suggests the sequence north-south-east-west.

19. H. HARTUNG, "Ancient Maya Architecture and Planning: Possibilities and Limitations for Astronomoical Studies." in *Native American Astronomy*, ed. A. Aveni (Austin: University of Texas Press, 1977), pp. 111-130.

20. H. HARTUNG, "Consideraciones sobre los Trazos de Centros Ceremoniales Mayas," in *48th Acts of the International Congress of Americanists*, vol. 4 (Stuttgart: Kommissionsverlag K. Renner, 1972), pp. 14–26.

21. A. AVENI, "Concepts of Positional Astronomy Employed in Ancient Mesoamerican Architecture," in *Native American Astronomy*, ed. A. Aveni (Austin: Univeristy of Texas Press, 1977), pp. 3–21.

22. H. HARTUNG,[16] pp. 33–42, plans 1–4 and H. HARTUNG, "A Scheme of Probable Astronomical Projections in Mesoamerican Architecture, in *Archaeoastronomy in Pre-Columbian America*, ed. A. Aveni (Austin: University of Texas Press, 1975), p. 203.

23. H. HARTUNG,[16] pp. 43–47, plan 5.

24. H. HARTUNG,[16] pp. 58–68, plan 7, figs. 21–29 and A.F. AVENI,[7] p. 125.

APPENDIX

Using the concept of a 3-4-5 right triangle and only a piece of string and three pegs, we were able to lay out rather precise right angles. Fortunately, the perimeter of this triangle has a length which is exactly divisible by two of the sides ($12 \div 3 = 4$ and $12 \div 4 = 3$). The method proceeds as follows: (1) Place two of the pegs at any distance apart. (A more precise right angle results when they are placed farther apart.) Designate this side to have a length of 3 units. (2) Then connect the pegs with a string four times to obtain a string of length equal to that of the perimeter, 12 units. (3) Divide the string into three equal parts and mark it at the end of the first part so as to determine the length of four units. (4) Connect the third peg to the string at the mark and the two ends of the string to one of the other pegs. (5) Loop the loose (8 unit) string around the remaining peg and pull at the peg marking four units until the string is straight between all three pegs. When this is done, there is one and only one position in which to locate the unplaced peg. This is a right triangle with an angle we find consistently to differ from 90 degrees by less than 10 minutes of arc. By successfully undertaking this exercise we do not imply that the Maya used this very method to lay out right angles, but we have shown how easily and accurately the task can be accomplished with only simple tools, basic geometry, and a small amount of thought.

Another interesting and useful fact that the Maya could have used to lay out right angles is that, when all three vertices of a triangle touch a circle and the diameter of that circle is also the longest side of the triangle, the triangle is always a right triangle. We determined in the field that a knowledge of this fact would have allowed the Maya to make right angles just as easily and accurately as by the previous method. They would only need to draw a half circle with string of constant length connected to the center point and then inscribe a triangle in the proper manner.

Astronomy, *Cosmovisión*, and Ideology in Pre-Hispanic Mesoamerica

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THE INTENT OF this article is to contribute a few considerations from the fields of ethnohistory and anthropology to the interdisciplinary approach of this volume. The point of departure for this investigation is the study of Aztec calendar festivals and their relation to society in Central Mexico on the eve of the Spanish Conquest, a study in which ritual is analyzed as a social phenomenon.

We will deal with certain aspects of pre-Hispanic astronomy from the point of view of its close interrelation with the calendrical system and with *cosmovisión*, relating these different elements to each other and analyzing them in terms of their ideological significance. The concept of ideology that will be used in this approach establishes the link between *cosmovisión* on the one hand, and social reality and economic and political structure on the other. Methodologically speaking, I will interpret ethnohistorical, archaeological, and astronomical data in terms of anthropological theory.

We also might indicate, in reference to the question of terminology, that by *cosmovisión*—a term borrowed from the common Spanish usage—we understand the structured view in which the ancient Mesoamericans combined their notions of cosmology into a systematic whole, while *ideology* will be used in a specific way denoting the basic approach of this paper. It implies a distinction between "objective social reality" and the "explanation" that the ancient Mesoamericans gave of that reality. Ideology is a system of symbolic representation, and its most important social function is to legitimize and justify the existing order of

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society. In this sense, ideology creates a "false conscience" of reality in societies, like pre-Hispanic Mexico, that have experienced the rise of social classes and the state.

Although it has long been a well-known fact that astronomy was highly developed in ancient American civilization, its serious scientific study is a latecomer to pre-Hispanic studies. These studies have registered great advances during the last decade, and it is only just to mention in this context that the most important single contribution is due to the work of Anthony Aveni, to whom we also owe the organization of this conference. His latest book, *Skywatchers of Ancient Mexico*, represents the culmination of many years of research, including the editing of two other books on archaeoastronomy.[1] These books established the study of American archaeoastronomy as a legitimate separate field of research, closely related to archaeology and ethnohistory. I would even say that, in Mesoamerican studies in general, the most interesting innovative results that have come to light during the past years have been in those aspects of field research related to pre-Hispanic agricultural systems, particularly in the Maya area, on the one hand, and in archaeoastronomy on the other. The conclusions reached in archaeoastronomy are based on fieldwork and can be checked by the methods of astronomical science. This circumstance adds a very important dimension to this young discipline; further stimulating results can be expected in the future.[2]

In this essay I assume that the reader is familiar with the general background of pre-Hispanic astronomy, as well as the basic structure of the calendar system.[3] This permits me to concentrate on certain specific points relating to the important dates of the solar year, in order to examine the interrelationship that existed between solar observation, the structure of the calendar, and the calendar festivals. As I have indicated above, the specific case studied concerns Aztec society and *cosmovisión* on the eve of the Spanish Conquest; however, I believe that the implications of my analysis are of a more general nature and might be extended to other regions and time-periods of Mesoamerica as well.

THE CALENDAR

The Mesoamerican calendar was one of the purest sun calendars known among peoples of antiquity. Its basic structure was the solar year of 360 + 5 days. It was combined with a ritual calendar of 260 days; it is not clear whether this cycle was based on the observation of nature or

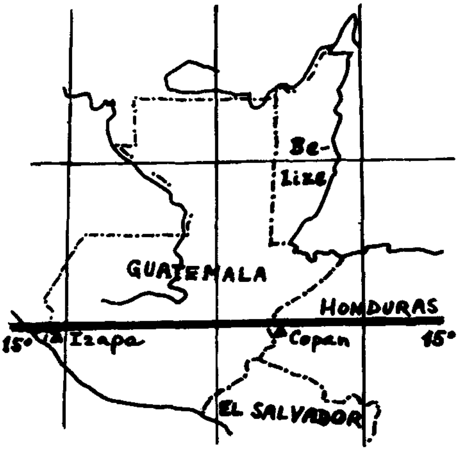


FIGURE 1. The latitude of 15° N: Guatemala and Honduras (Izapa and Copán).

resulted from a combination of the ritual cycles of 13 and 20 days. Its natural basis might have been the period between the two passages of the sun through the zenith in the geographical latitude (approx. 15°N) of the ancient Maya centers of Izapa and Copán (FIGURE 1).[4] Thus, the most plausible natural explanation of this cycle might also be a solar one.

The combination of the cycles of 365 and 260 days resulted in a larger unit of 52 years, the Calendar Round, which was the basic unit of Mesoamerican chronology, in its so-called Short Count (*xiuhmolpilli*, or "Bundle of Years"). At its end, the Aztecs celebrated a big festival, called the "Binding of the Years." In it, they kindled New Fire, which symbolized that the world would continue for another 52-year period. The celebration of this festival coincided with the date the Pleiades passed the meridian at midnight (November 18). We will return later to the interesting question of the annual cycle of this constellation.

While the ancient Maya developed a sophisticated knowledge of the moon's course, which they registered in complex tables of lunations and eclipses,[5] no record of such calculations survived the Conquest in Central Mexico. Although we must assume a certain familiarity with these computations all over Mesoamerica, they seem not to have been integrated into the structure of the calendrical system, but, rather, to have remained property of a restricted priestly class. In the Central Highlands this subject requires considerably more research than it has so far received.

The Maya were also quite knowledgable about the Venus cycle and

brought it into tune with the solar year. Every 8 years, the solar year of 365 days coincided with the cycle of Venus of 584 days, a circumstance that received great attention in terms of the calendar as well as of ritual.

It is a fact that 16th century ethnohistorical sources from Central Mexico do not reveal, by themselves, the importance of solar events. The Spanish friars who wrote these chronicles were neither particularly interested in nor aware of astronomical phenomena, and the indigenous sources (pictographic documents and sources transcribed in Nahuatl) also do not refer explicitly to these events; their language is highly symbolic and hides astronomical implications behind metaphors. The key to deeper penetation of the enigma of Mesoamerican archaeoastronomy has emerged recently from a systematic study of the orientation of Mesoamerican architecture.

The coordination of space and time in Mesoamerican *cosmovisión* found its expression in the orientation of pyramids and architectural complexes. These structures are in many cases oriented in relation to the ocurrence of sunrise or sunset on specific days of the solar cycle. Taking up the sporadic attempts at measurements undertaken earlier by a number of authors,[6] A. Aveni and H. Hartung have, in the past ten years, made systematic field measurements of the orientation of archaeological complexes with the surveyor's transit, which are now complete enough to permit one to draw statistical conclusions. These data constitute a firm basis for any further analysis.[7] Franz Tichy, on the other hand, has combined the investigation of this type of measurements with the study of the cultural landscape as it can still be observed today in the Central Highlands of Mexico. Tichy's interdisciplinary approach, combining astronomy with cultural geography and ethnohistory, has yielded a series of interesting insights into the ancient Mexican calendar and its relation to *cosmovisión*. Some of his intriguing hypotheses still need further testing.[8]

The aforementioned studies have established the fact that numerous pre-Hispanic pyramids and buildings were oriented towards the direction of sunrise or sunset on the main dates of the sun's yearly cycle, i.e., the days of the solstices, the equinoxes, and the zenith. Thus, it was the objective existence of these orientations in archaeological complexes, observable today, that drew attention to the importance of the solar dates corresponding to these orientations and that has stimulated further investigations into the cosmological implications of these facts.

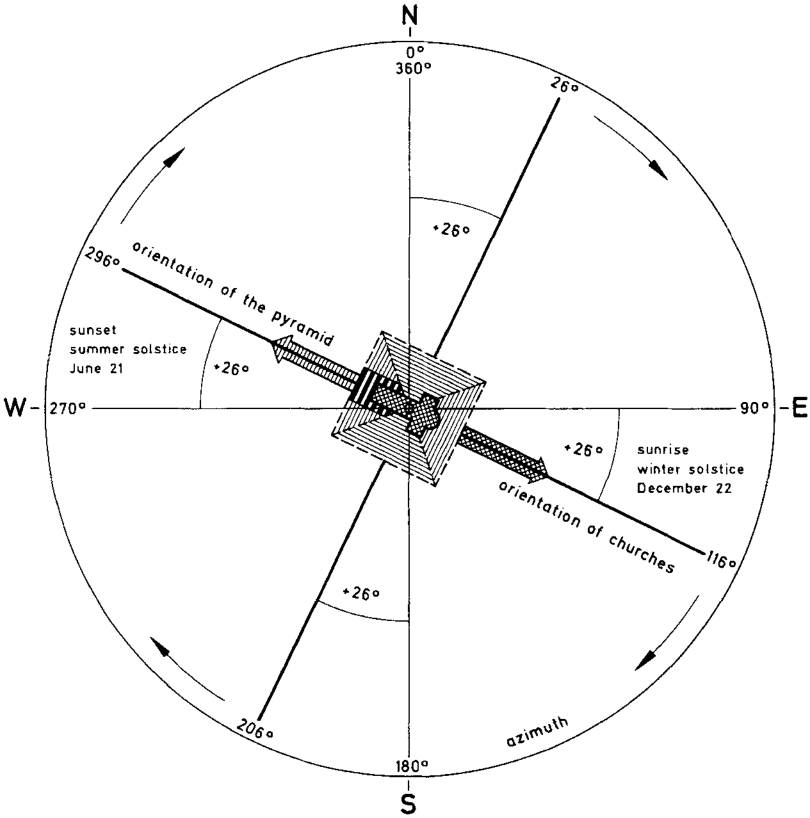


FIGURE 2. The orientation of the pyramid of Cholula in relation to the solstices (the exact angle is 294° 45′). (From Tichy,[8] "Ordnung," by permission of the author.)

THE SOLSTICES

It appears that, among solar phenomena, the ancient Mexicans attributed the greatest importance to the solstices, particularly the summer solstice.

The orientation of the great pyramid at Cholula with 294° 45′ corresponds to sunset on the summer solstice (21 June), or to sunrise on the winter solstice (22 December).[9] The priest who stood in front of the temple at the summit of the pyramid performing certain rites could observe sunset on the day of summer solstice at a point on the horizon deter-

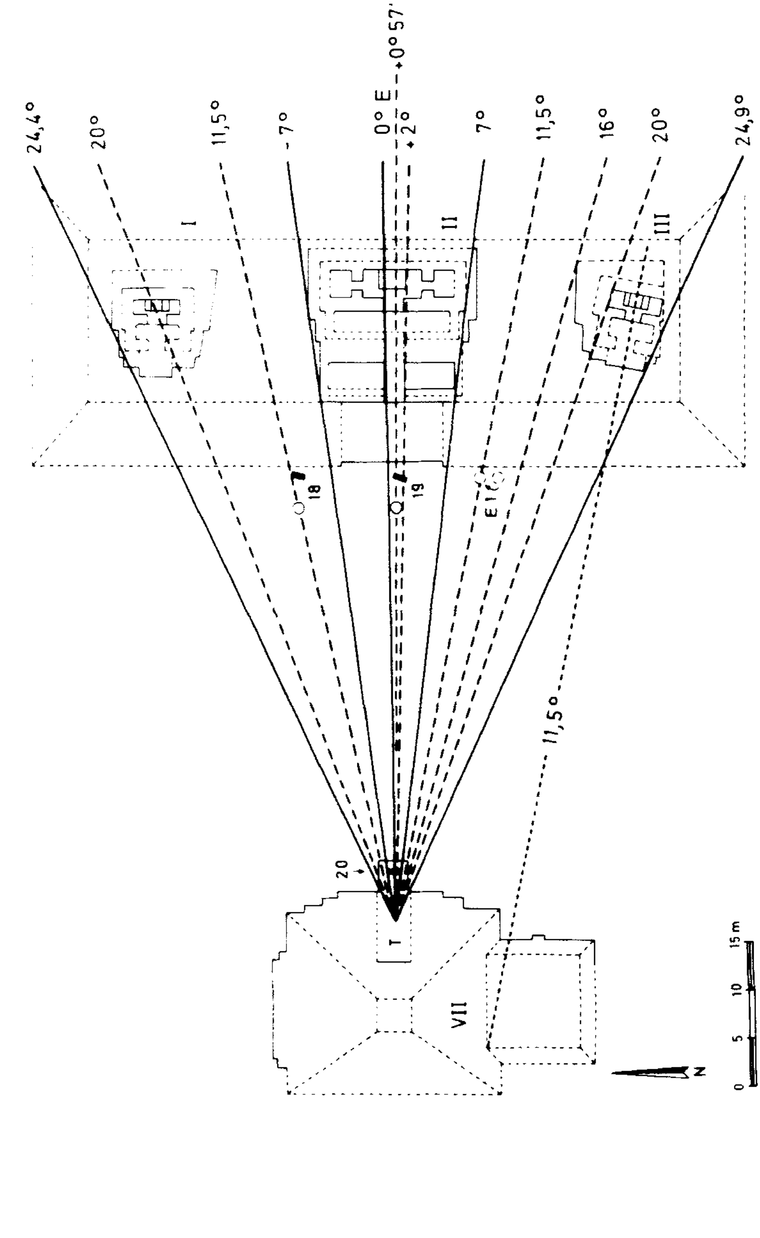


FIGURE 3. Building E at Uaxactún. The two extreme points are the solstitial angles; the middle point is true east and the direction of midyear (0° 57'). (From Tichy,[8] "Ordnung," by permission of the author.)

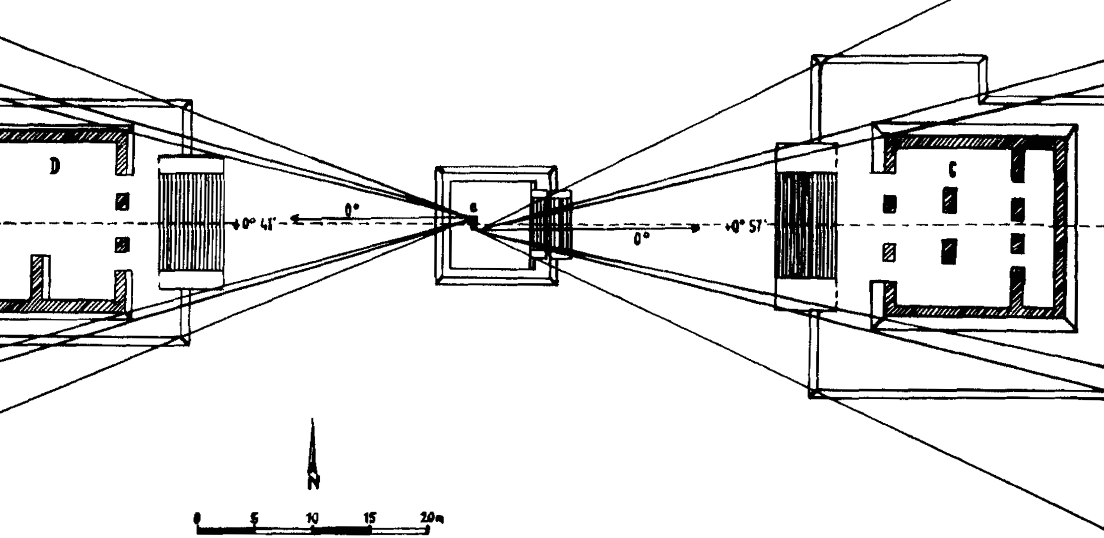
mined by the axis of the temple and the pyramid, an event that repeated itself every year on the same day (FIGURE 2).[10,11]

The easiest way to fix the solstice is by observing the annual movement of the sun on a straight line on the eastern or western horizon. Seen from an observatory at a certain distance, the equinoxes mark the middle point (0°) on the horizontal line, while the solstices determine the two extreme points, with symmetrical angles of approximately 24.5° (for latitudes 15°–19°N), the so-called solsticial points. An observatory of this kind was found at the Maya site of Uaxactún (building E) and dates from pre-Classic times (FIGURE 3).[12] According to Tichy, another one existed at Xochicalco, in combination with the architectural complex C + D (FIGURE 4).[13] R. Fuson points out that some 18 observatories of this kind have been discovered in the Maya area.[14] One of these, the astronomical observatory at Xochicalco, a chimney built into an artificial subterranean chamber, is constructed in such a way that it captures a beam of sunlight at noon on the day of the summer solstice (FIGURE 5).

By means of the four solsticial points (including the sunrise as well as the sunset positions), one can draw a diagram, which, in pre-Hispanic times, was a highly important symbolical representation and can be found on numerous archaeological pieces. U. Köhler derives the symbolism of the Aztec day sign *olin* ("movement", "path") from this solsticial diagram and proves that its origin was an Olmec model from pre-Classic times (FIGURE 6).[15] According to Girard, these representations are called "cosmic diagrams;" he describes their ritual use among the Chorti of modern Honduras.[16] Still surviving ethnographic data have been reported for other Indian groups, particularly in the Maya area.[17]

THE EQUINOXES

The cardinal directions of east and west were fundamental in Mesoamerican *cosmovisión*. The east was the point of reference for the other directions. Yet these two directions, corresponding to an azimuth of 90° for 21 March and an azimuth of 270° for 23 September respectively, are extremely rare in the orientation of pre-Hispanic buildings. The reason seems to lie in the geographical conditions of Mesoamerica; there, the equinoxes do not constitute as outstanding a climatological phenomenon as they do, e.g., in Europe. In Central Mexico, the difference in the length of the day between 21 June and 22 December is only 2 h 20 min, in contrast to 8 h 30 min in the European latitude of 50°.[18]



Pyramids C and D at Xochicalco. The most interesting angles are 25.5°, sunrise on 22 December, the winter solstice
tly before the zenith passages on 15 May and 29 July; and 0° 57', which marks the days that divided the year into equal
m is from Tichy,[8] "Calendario;" measurements by Aveni, Jan. 1977, and Tichy, 1975 and 1977.

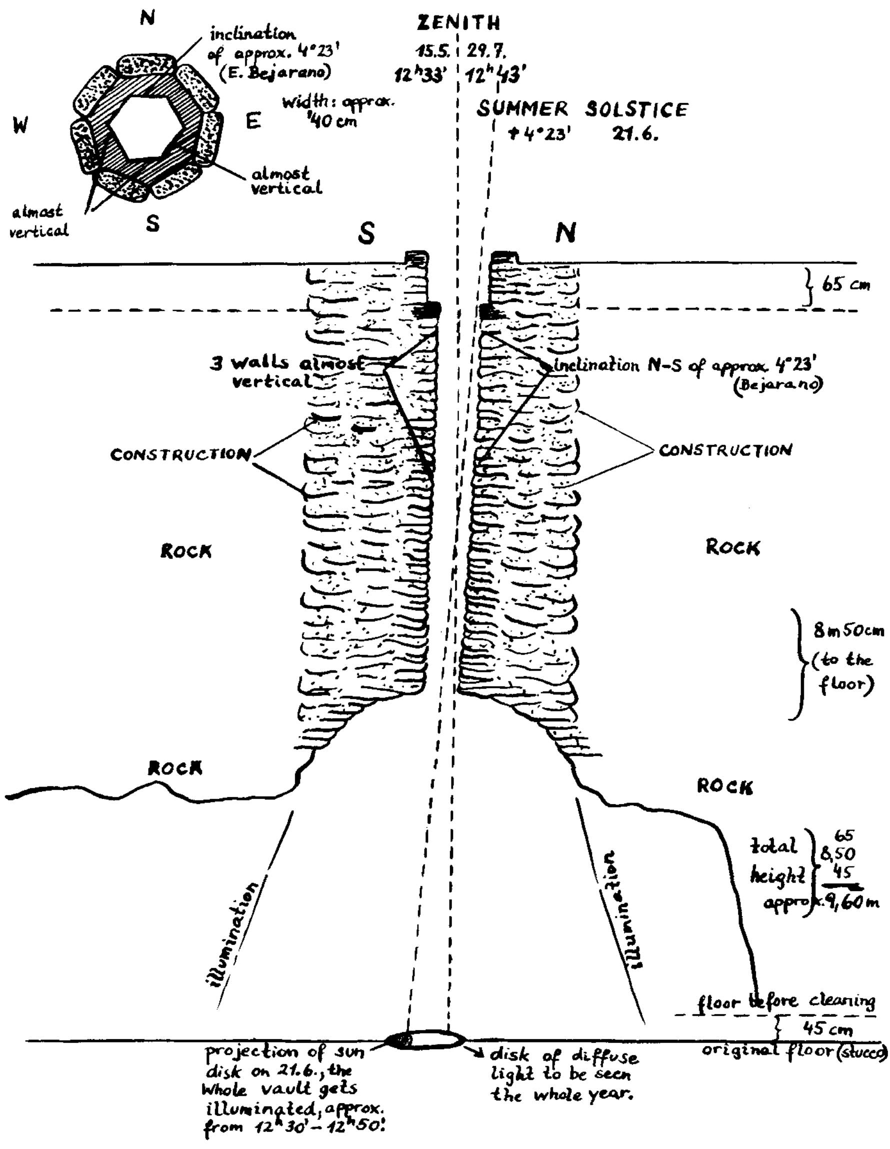


FIGURE 5. The astronomical observatory at Xochicalco. The latitude of Xochicalco is 18° 46′ N. The drawing is based on Tichy,[8] "Festkalender," and personal communication from E. Bejarano, director of the Centro Regional del INAH, Morelos, to the author; 21 June 1980.

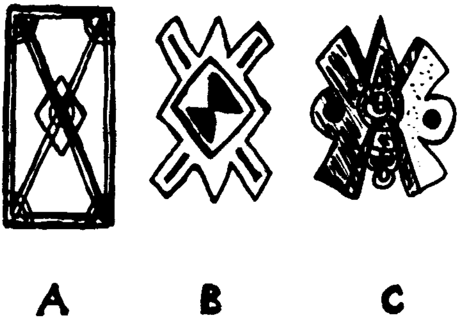


FIGURE 6. Cosmic diagrams: (A) La Venta, (B) Teotihuacan, and (C) the Aztec day sign *olin*. (From Köhler.[15])

Tichy points out that, instead, the ancient Mexicans seem to have attributed more importance to the days that divided the year into equal halves, i.e., March 24 and September 20, which account for a division in which the winter half is 8 days shorter than the summer half, than to the equinoxes. To the former date corresponds the angle of 0°57′ deviation E to S, which, according to Tichy, can be found in the axes of the calendrical buildings of Uaxactún and Xochicalco (FIGURES 3, 4).[19]

THE ZENITH PASSAGES

The geographical latitude of Mesoamerica offers one the possibility of observing the two passages of the sun through the zenith in its annual movement between the equator and the Tropic of Cancer (lat. 23°26′ N), the point it reaches on the day of the summer solstice.[20] Between the two zenith passages, the sun moves to the north of the respective latitude of the zenith, an astronomical fact that is reflected in Aztec mythology in the concept that the sun enters the Mictlan, the abode of the dead situated to the north, during *Toxcatl*, the month of the first zenith passage.[21] This observation, which is impossible to make in latitudes north of the tropic, provides the cultures situated between the tropics with certain calendrical advantages, which have not yet been sufficiently explored in all their many dimensions.

The zenith passage of the sun is not only important insofar as the observation of that heavenly body is concerned, but the climatological phenomenon of the rainy season also depends on it, as well. The first passage of the sun through the zenith announces in Mesoamerica that the rains will start soon, which, in turn, is the necessary condition to begin the planting of maize. This interrelationship also found an expression in

myth and ritual in ceremonies related to maize and water. We will return to this point later, since it is fundamental to the understanding of the intimate association that existed between astronomical observation, climatological phenomena, agriculture, and ritual.

On the other hand, the zenith passages were also highly relevant in calendrical terms, since they provide a way to check the correspondence of the calendar and the solar year twice a year. It is easier to observe the zenith than the solstices or equinoxes since, at the latter dates, the sun's position changes only very little from one day to the other, and the difference in its movement is hardly visible.[22]

Observations of the zenith passage could be made in vertical tubes built into pre-Hispanic archaeological complexes like the one in Building P of Monte Alban (FIGURE 7)[23] or the artificial subterranean chimney forming part of the central precinct of Xochicalco.[24] Interestingly enough, the observatory at Xochicalco not only makes it possible to observe the

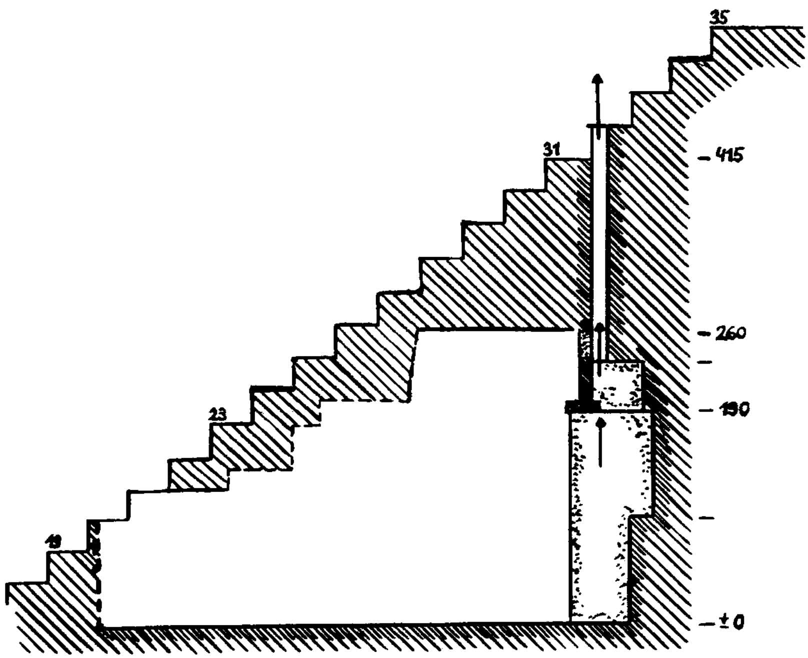


FIGURE 7. The zenith tube at Monte Alban, Building P. (Diagram by Hartung, by permission of the University of Texas Press; see Aveni,[1] *Skywatchers*, figure 85a.)

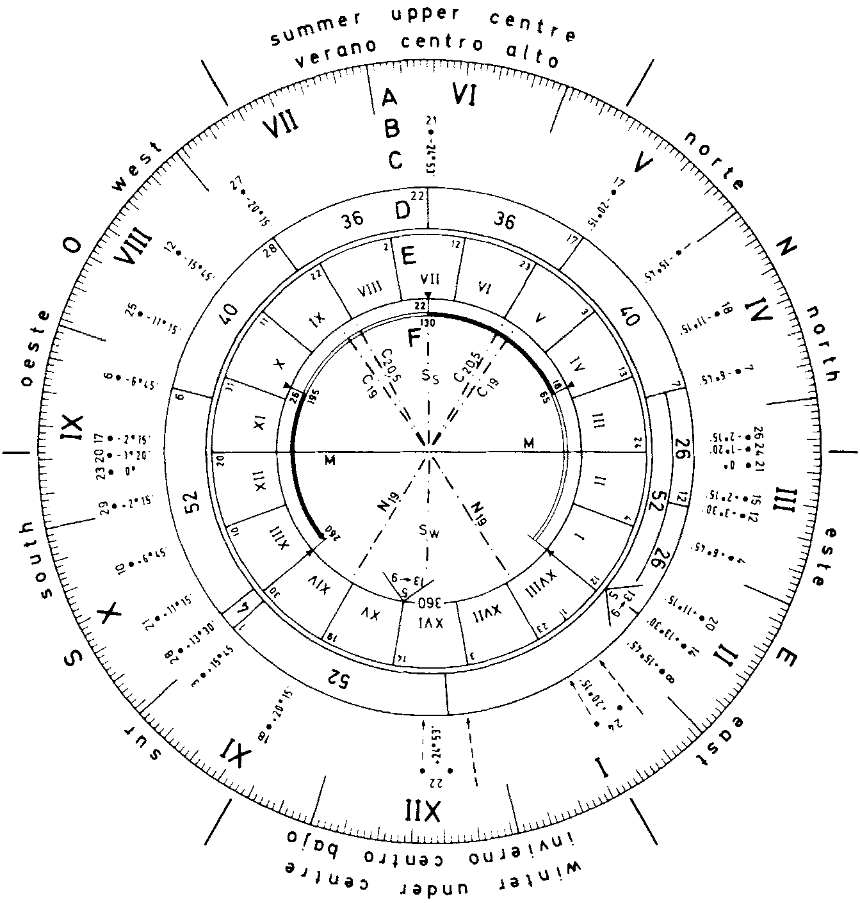


FIGURE 8. Tichy's calendar correlation and the orientation of pre-Hispanic buildings. (Diagram by Tichy, 16 Dec. 1977, by permission of the author.) A: Gregorian calendar 1975, B: days with specific directions of sunrise and sunset, C: axial deviation of pyramids, negative angles of sunrise in summer from east to north, positive angles in winter from east to south, D: "fixed *tonalpohualli*," or a solar calendar with 260 days plus 100 days and 5 days "*nemontemi*," divided into unequal periods, E: "Calendario Mexica," with 360 plus 5 days. 18 periods of 20 days and 5 *nemontemi* (9 to 13 December). The *nemontemi* are usually placed before I *Atlcahualo*, which begins on 12 February. This date for the beginning of the year agrees with Sahagún. The six groups of 60-day periods coincide with the six quarters of the universe, F: *Tonalpohualli* with 260 days, divided into four periods of 65 days or twenty thirteen day weeks, S_S and S_W: summer and winter solstices, C_{19} and $C_{20.5}$: zenith passages of the sun at latitudes 19° and 20.5° N, M: midyear days, 24 March and 20 September.

zenith passage, but its main orientation seems to be towards the summer solstice (FIGURE 5).[25] The latter construction also permits one to observe that, during the period between the two zenith passages, the sun moves to the north, while its beam of light (or shadow) will be projected to the south.

Observatories of this kind could serve to determine the true length of the tropical year, i.e., to observe that, every four years, one additional day had elapsed when the date of the zenith passage occurred. This method, which has recently been suggested by Tichy,[26] might give a clue as to how the ancient Mexicans brought the vague year of 365 days, which was a mathematical necessity within their calendrical system, into correspondence with the true solar year. There must have existed some pragmatic method of correlating mathematical cycles and solar and climatological phenomena, otherwise the calendar festivals would have fallen out of tune with the seasonal cycle.[27] Yet, an agricultural calendar that, in the practice of daily life, did not correspond to the seasons would have been useless in a society whose basic sustenance was agriculture.

In the context of these studies, Tichy has worked out a fixed correlation for the Aztec calendar. This correlation draws upon numerous elements derived from the orientation of buildings, solar dates, and aspects of the internal symmetry of the calendar, which I cannot, for lack of space, discuss in any greater detail; in general terms, Tichy's results confirm the correlation given by Sahagún, according to which the month of I *Atlcahualo* began on February 12 (FIGURE 8).[28] Only on the basis of a fixed correlation is it possible to analyze the astronomical content of the calendar festivals. Naturally, I am aware of the fact that there still remain many unresolved problems related to the correlation question.[29]

THE CEREMONIES

CALENDAR FESTIVALS, WORSHIP OF THE SUN, AND AGRICULTURE

So far, we have discussed the coordination of time and space as expressed in the orientation of buildings, which reflected solar observation and calendrical practice. The religious and social dimension of the calendar system was ritual. We are particularly fortunate in the case of Aztec ritual on the eve of the Spanish conquest, since we have elaborate descriptions of the 18 monthly festivals by Spanish chroniclers as well as several texts in Nahuatl.

One major festival was celebrated during each of the 18 months of 20

days. Besides these great festivals, minor celebrations and ceremonies took place, creating a ritual structure that ran throughout the whole year and was closely connected to seasonal and agricultural cycles, as well as to social activities. Within the complex yearly structure of ceremonies, a specific structure referring to the sun cult is clearly recognizable. However, the solar symbolism is embedded in the symbolism of deities and ceremonies, and is also related to the social groups that participated in these festivals.

The first passage of the sun through the zenith corresponded in the latitude of Tenochtitlan to 17 May, and coincided with the Aztec festival of V *Toxcatl* dedicated to the great gods, Tezcatlipoca and Huitzilopochtli, whose worship was the obligation of the ruling class. Several authors have considered *Toxcatl* the most important annual festival, as well as the first month of the year.[30] The second zenith passage corresponded in Tenochtitlan to 27 July and to the month of IX *Miccailhuitontli-Tlaxochimaco*, when the Aztecs worshipped the god of the underworld, Mictlantecuhtli, and the deceased who had departed to his abode. They also brought offerings of flowers to their patron god Huitzilopochtli (FIGURE 9).

These offerings to the dead—which also took place during the earlier month of *Toxcatl*—seem to convey the indigenous belief that, between its two zenithal passages (May and July), the sun entered the Mictlan, the abode of the dead situated to the north. In fact, as we have pointed out before, in Tenochtitlan the sun passed to the north of the geographical latitude during this period (FIGURE 9).[31]

The summer solstice coincided with *Tecuilhuitontli*. The two months VII *Tecuihuitontli* and VIII *Huey tecuilhuitl*, "the small and great festival of the lords," contained numerous elements that indicated the solar cult in relation to the cult of maize. They were also the most important festivals of the year for the ruling class; these ceremonies expressed, in a symbolic way, the function of the supreme ruler to look after the well-being of his subjects, including the poor of Tenochtitlan.[32]

The winter solstice corresponded to the month of XVI *Atemoztli*, when dogs were sacrificed to the sun in order to help it in its voyage across the river of the underworld.[33] The very name of the month, *Atemoztli*, might be understood as "Descent to the Water," meaning the descent of the sun to the waters of the underworld.[34] The month preceding *Atemoztli* was XV *Panquetzaliztli*; on its last day, the Aztecs celebrated the festival of the birth of Huitzilopochtli, which is considered

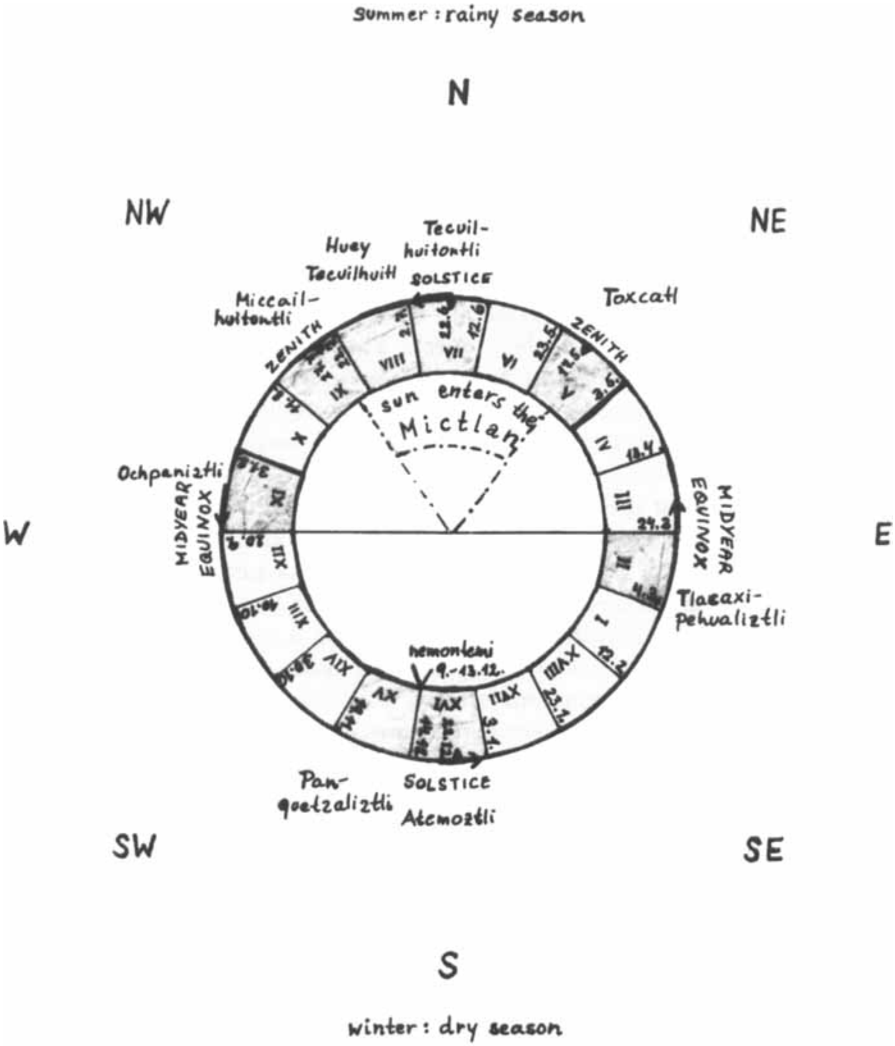


FIGURE 9. The solar cycle of Aztec festivals. Sequence of the diagram: counterclockwise, E-N-W-S. (Correlation by Tichy, author's diagram, 1981.)

to have been their "national" fiesta. It should be kept in mind that their patron god Huitzilopochtli was a solar deity.

Finally, we must mention II *Tlacaxipehualiztli* and XI *Ochpaniztli*, the two months in which fell the equinoxes, as well as the days that astronomically divided the year into equal halves (March 24 and September 20) (FIGURE 9). Both festivals were extremely rich in symbolic and dramatic elements and were, in certain ways, analogous. Their main gods, Xipe and Toci (male and female, respectively), were sacrificed by flaying and their ceremonies were intimately related to fertility and agriculture, as well as warfare. Their bloodthirsty worship was a duty of the warrior caste.[35]

The symbolism of the festivals we have mentioned, as well as the variety of gods, rites, and symbolic elements implicated in them, indicates the complexity of the subject. The correspondence between astronomical phenomena and Aztec rites was not a direct one, since it was the result of a long historical process. The origins of this process go back to the very beginnings of Mesoamerican civilization; historical documentation, however, is practically absent for these early periods.

In the course of the evolution of this correspondence, observational contents and practical requirements of the ceremonies became embedded in numerous layers of symbolism that came to acquire manifold and sometimes contradictory meanings. Yet it is valid to say that the basic structure of the ritual calendar was derived from a combination of solar observation and the needs of the agricultural cycle. A fundamental concern of ritual was with rain and fertility, as is to be expected of a culture that derived its sustenance from agriculture. The natural environment of Mesoamerica was characterized by extreme climatololgical and geographical conditions. During the dry season, there was a constant lack of water, while, during the rainy season, the waters could be dangerous in their excess. Thus, the obsession with rain and water in Mesoamerican religion had a direct material basis. This cult had become, among the Aztecs, the concern of the priests and the peasants, while the nobles and warriors participated in warlike cults with a different mythological content (like the worship of Xipe, Huitzilopochtli, Tezcatlipoca, etc.). Interestingly enough, the festivals with the most outspoken ideological content, in which the mission of the warriors and Aztec rulers was glorified, proclaiming their aspiration to political domination, were precisely those festivals related to the sun cult.

In the structure of festivals dedicated to the sun, we find that the cult of the great deities, and the cult of the dead and the underworld, were in-

timately related to warfare. At the same time, these ceremonies contained explicit references to the cult of maize and fertility. Thus, warfare, fertility rites, the solar cult, and the cult of the dead were conceptually associated in the ideology of the Aztec state cult. Another important point is that this ideology as well as participation in these ceremonies were basically the concern of the ruling class.

THE NEW FIRE CEREMONY

THE CULT OF THE PLEIADES AND THE SUN

The New Fire Ceremony was intimately related to the cult of the Pleiades as well as the solar cult and marked an important point in the intricate structure of the calendrical system. Every 52 years, as one of their large calendar cycles approached its end, the Aztecs believed that there existed an imminent danger that the world might come to a standstill. They then celebrated the festival of the "Binding of the Years." New Fire was kindled in the breast of a sacrificial victim to symbolize the beginning of a new calendrical cycle and the triumph over the dangers of destruction. This festival took place during the middle of November, at the time of the year when the Pleiades passed the meridian at midnight and were clearly visible during the whole night.

A closer analysis of the annual cycle of the Pleiades, which I have undertaken in a different study,[36] reveals not only that they were an extremely important constellation all over the Americas – including North and South American tribal areas as well as the Andean civilization and Mesoamerica – but also that, in the latitude of Mesoamerica, their calendrical importance in relation to the solar cycle was extraordinary. Their annual cycle must have appeared to the pre-Hispanic observer as a "course contrary to the sun" (TABLE 1). Their heliacal rising took place at the end of May after they had disappeared from sight for approximately four weeks. May is precisely the month of the first zenithal passage of the sun. Half a year later, during the month of November, the Pleiades are brightly visible during the whole night, passing the meridian at midnight. Thus there existed a certain "opposite symmetry" between the course of the sun and that of the Pleiades. The zenith passage of the Pleiades took place when the sun was situated at its nadir, i.e., during the month of November. Naturally, one has to take into account the fact that the zenith is the only date in the solar cycle that varies from one region to another; but perhaps it is precisely this fact that explains the importance

TABLE 1[37]

THE CYCLE OF THE PLEIADES: YEAR 1500 A.D. – LATITUDE 21° N

26 April–29 May (3 May–4 June) *Period of invisibility*	The Pleiades are not visible. During this period, the first passage of the sun through the zenith occurs at Tenochtitlan (17 May).
29 May (4 June) *Heliacal rising (dawn)* (The Pleiades rise in the east at dawn, before sunrise, in parallel with the sun.)	This is the first day on which the Pleiades rise in the east before dawn. From this date on they rise earlier than the sun each day until November. During this period they are, at first, seen only at dawn; progressively, they can be seen during a longer span of the night until dawn.
1 November (7 November) *Heliacal setting (dawn)* (The Pleiades set in the west before dawn and rise after sunset in the east, contrary to the sun.)	The Pleiades appear after sunset in the east. Between 1 and 18 November they can be seen from sunset (rising in the east) to sunrise (setting in the west), i.e., during this period they are visible throughout the night.
16 November (22 November) *Zenith at midnight*	The Pleiades pass the zenith at midnight. This date coincides with the nadir of the sun at Tenochtitlan (six months after 17 May).
18 November (25 November) *Heliacal rising (dusk)* (The Pleiades rise in the east after sunset and set in the west before dawn, contrary to the sun.)	The Pleiades begin to set in the west before dawn. From November to January, they are visible from sunset (rising in the east) until sometime before dawn (setting in the west).
26 April (3 May) *Heliacal setting (dusk)* (The Pleiades set after sunset in the west, in parallel with the sun.)	From 18 November until 26 April the Pleiades set earlier each day until, on 26 April, they set in the west before sunset. This means that they disappear from sight for a period of approximately one month, until, on 29 May, they begin to rise again in the east at dawn.

NOTE: The 1980 dates are given in parentheses. All these dates only have an approximate validity; variations in atmospheric and topographical conditions can cause a difference of several days.

that XV *Panquetzaliztli* (corresponding to November) and V *Toxcatl* (corresponding to May) acquired in the Valley of Mexico, two festivals in which the solar symbolism played a particularly significant part in the ceremonies.

The importance of these observations lies in the fact that, up to now, very little was known about the existence of the concept of the nadir in Mesoamerica. Yet we do know that this concept played an important role in the Andean region, as recent studies by T. Zuidema,[38] G. Urton,[39] and A. Aveni[40] have demonstrated. To the Incas, this date symbolized the dualism of the vertical-antivertical axis that was fundamental to their *cosmovisión*, a tradition that still survives in parts of the Andean region today.

Another circumstance worth mentioning in relation to the Pleiades is their close association to the rains and, indirectly, to the fertility of crops. The disappearance of the Pleiades from the night sky at the end of April was interpreted as a sign that the sun would soon reach the zenith and, also, that the rains would start soon. During the months of April and May, the planting of maize still takes place all over Mesoamerica; its precise timing varies according to the altitude and ecological conditions of each region. While, in the Maya area of Southeastern Mexico and Guatemala, the zenith passage of the sun coincides in the first days of May exactly with the sowing season and the beginning of the rains, the coincidence is not quite as close in Central Mexico. On the other hand, the sun's position at nadir during November coincides not only with the zenith passage of the Pleiades but also with the beginning of the dry season all over Mexico. During the latter part of the year, the sun is more dominant in the sky than during the rainy season. This fact seems to be reflected in the important mythical relation the sun had with the Aztec months of November and December, symbolized in the sun's birth during the festival of *Panquetzaliztli*, and its passage through the river of the underworld during *Atemoztli*, the month of the winter solstice.[41]

ASTRONOMY, *COSMOVISIÓN*, AND THE STRUCTURING PRINCIPLES OF THE UNIVERSE

In the preceding pages we have tried to illustrate the intimate connection that existed between certain astronomical observations, the structure of the Mesoamerican calendar, and the Aztec monthly ceremonies. The examples we have given show the complexity of the matter. Nevertheless, it seems possible to draw two kinds of conclusions: (1) On the one hand,

we can demonstrate the observational basis of the ritual calendar; its basic structure was derived from solar observation and was combined with the observation of certain other astronomical phenomena. Its practical utility derived from its link to seasonal cycles, as well as to social activities. The division of the year into the dry and the rainy season is recognizable in Aztec ritual, as is a reference to the different cycles of rainfall and irrigation agriculture.[42] (2) However, in this paper we are not so much interested in exploring the multiple dimensions of the cult itself — this I have done in other studies[43] — rather, we want to put the emphasis on the particular mental and social processes by which astronomical observations became immersed in myth and ritual, thus leaving behind the terrain of "objective" scientific knowledge. In this sense, the cult system is a good example, since one of the main objectives of pre-Hispanic astronomy was to express its observations in mythical terms and, thus, to provide the basis for the execution of rites and sacrifices.

In pre-Hispanic astronomy we find an intimate relationship between scientific observation and mythical thought. To achieve the "predictability" of natural phenomena is a fundamental goal of modern science. This was also a goal of intellectual effort among the ancient Mesoamericans. Nevertheless, there are certain fundamental differences. One of the questions arising from the concrete material is, by which specific mental processes did scientific observation transform itself into mythical thinking? To what extent did they achieve the prediction of those natural phenomena which they wanted to control, and why did this endeavor transform itself at a certain point into myth, ritual, and ideology?

With respect to the "applicability" of observations, we have seen that they could be used to predict astronomical and climatological phenomena. Nevertheless, there was more to it than that. Since cosmos and society were conceived as a unity in ancient Mesoamerica, the purpose was to learn about the laws of nature, not only to discover them, but to regulate social life as well. This conception is fundamentally different from that of the modern scientific mentality. From this particular nexus was derived the importance of astronomy and calendrics within ideology. We are dealing here with a complex process. Since natural laws have been discovered, it is possible to make correct predictions at many points. In addition, these regularities and the recurrence of the phenomena discovered are characterized by internal mathematical relations. This fact increases the "predictability" of natural phenomena, yet it does not mean that, in all cases, an exhaustive objective explanation had been found for them.

It is necessary to distinguish between the "discovery" of phenomena, their regularities, and natural laws, and the "explanations" that are given for these phenomena. In ancient Mesoamerica, the conclusions drawn from observed processes were often of a nonscientific character. The reason for this was that the purposes of explanation were other than those of modern science. In the integration of ideology and politics with the socioeconomic structure and the material basis of society, there was such an intimate mixture of the elements of the ideology and those of the infrastructure that it is not possible to separate them into two distinct entities. Thus, astronomical observation and calendrical science formed an important part of the ideology, which gave cohesion to that society and functioned as an instrument of power in the hands of the ruling class.

By means of astronomical observation and the application of the mathematical laws contained within the calendrical cycles, the ancient Mexicans endeavored to create an enduring system of order encompassing human society as well as the universe. In spite of the numerous transformations that doubtless took place throughout Mesoamerican history, since pre-Classic times there had been a great continuity, a kind of leitmotiv, with respect to the effort of "imposing an order on the chaos" of natural phenomena. This "chaos" was clearly evident in the geographical conditions of Mesoamerica—a region of volcanic activity, consisting of a great variety of altitudes and ecological zones. Its climatic conditions were also prone to chaos and natural disasters: with respect to the extreme temperatures between day and night and between sun and shade; with respect to torrential rains, inundations, frost and hail on the one hand and extreme heat and droughts on the other. On the social level, Mesoamerica can also be characterized by a rather varied history; since remote times, this area has experienced the interaction of numerous peoples, migrations, and constant inter-cultural contacts.

We can observe this effort to "impose order on chaos" in the following spheres of Mesoamerican culture throughout its historical evolution:

Architecture. We can detect two opposing tendencies in Mesoamerican architecture: a tendency to achieve harmony with nature within the architectural context, creating a cultural replica of the environment, and a tendency to differentiate architecture from the surroundings. The latter effect was achieved by means of straight lines, constructions of plain stone, platforms, and pyramids, which established a sharp contrast to the vegetation in the vicinity. This applies particularly to the tropical regions. The use of red color on the buildings and pyramid walls also evoked an artificial distance from the natural setting. In this way, ancient Mesoamerican architecture created an artificial order in contraposition

to nature; it imposed a new structure, a "human order," upon the "natural order".

The Calendrical System. As we have seen, the calendrical system imposed a cyclical order derived from astronomical cycles upon social life. In this sense, the calendar established a relation between the cosmos and society, binding both into one single system. In the related branch of astrology (which was exuberantly developed on the eve of the Conquest), the objective was to extend the same "predictability" of natural phenomena to social and individual life. In this field, Mesoamerican man left the terrain of scientific observation completely behind.

The Orientation of Buildings and Archaeological Sites. Calendrical sciences, astronomy, and architecture were combined into a single *cosmovisión* by means of the orientation of buildings and archaeological sites. In this way, a truly "new order" was created as a unique structure of time and space, representing a mirror of the cosmic order (as revealed by the course of the constellations). We know that other ancient civilizations also endeavored to achieve this goal; nevertheless, in Mesoamerica it seems to have reached an astonishing degree of elaboration and perfection.

Indigenous Chronology and Historiography. Indigenous historical chronology also reflects an effort to combine the calendrical record with the record of historical periods. This "cosmic history" includes the *Leyenda de los Soles*, which, I believe, reflected the historical experience of Mesoamerica.[44] The origins of ruling dynasties were also situated in such cosmic periods. The government of rulers frequently lasted 52 years, i.e., exactly one major calendrical cycle; certain events took place on specific calendrical dates that repeated themselvs periodically; the birth dates of rulers and priests were highly symbolic, as well as the dates of their deaths. The calendrical counts of different peoples and ethnic groups did not only represent a temporal-spatial order, but were, at the same time, a geographical-political ordering of society, as Paul Kirchhoff has demonstrated in several studies.[45]

Ritual. On the one hand, Aztec cult was based on the calendar, depending on its cyclical recurrence, and on the other hand, it was the concrete realization of the relation defined by myth. The rites took place in the temples and ceremonial precincts that formed the center of the settlements. Thus, they established a link between architecture, calendrics, myth, and society. Ritual being fundamentally a system of social action, it imposed a socially defined order upon society, justifying it ideologically in terms of the cosmic order.

In this context I would like to quote the words of the eminent investigator of ancient Mesoamerica, Paul Kirchhoff, which adequately summarize the considerations we have presented above. This quotation is taken from his unedited notebooks, which came to light after his death. Its style is sketchy and peculiar, but it is precisely these characteristics that give it its charm:

> Ancient Mexico is a world of order, in which everything and everybody has his proper place. Thus, ancient Mexico could not have existed without an enormous mass of people that work according to what they are told to do. Man has formed for himself a very orderly image of the world. It is a world in which man has formed a unity in everything. Everything has its perfect place, there is a formula for everything; it is also a world that terrifies us because of its universality.
>
> Religion is conceived as a whole with the universe, a fact that gives great security to man. Everything has a visible structure, everything has a center. One world is destroyed and another world returns; everything is predestined. All things have their place because thus it has been prophesized. Architecture and calendrics are structuring principles: the calendar is a two-fold structuring principle, with time and with space. These cultures do not know chaos.
>
> One discovers things that appear to be disorder according to our judgment, but afterwards one discovers a much more fantastic order, e.g., that there exist a multiplicity of parallel calendars. The orderly structure can be seen in everything. . . .[46]

COSMOVISIÓN, IDEOLOGY, AND SOCIETY

It is necessary to place the considerations I have presented in this essay within the context of social reality. The concept of ideology establishes that link between religion and society. According to this approach, religion is viewed as the main expression of ideology in ancient Mesoamerican civilization and ritual as the fundamental vehicle by which that ideology was put into practice.

We understand religion as a system of symbolic representation and of action and are interested, above all, in inquiring about the social functions of this system. The underlying assumption consists of the proposition that religious theory (myth) and practice (ritual) had an important function in legitimizing the existing sociopolitical and economic conditions. Legitimization means, in this context, a coherent formulation about the structure and articulation of the social system as well as its relation to nature. Besides furnishing this coherent conceptualization,

religious ideology also propagated a system of action that was symbolically enacted—transformed into reality—by means of rites and sacrifices. Its content was expressed by myth.

It should be further pointed out that, in addition to the synchronic-functional approach, we are interested in the historical development of the institutions studied. Supposing that religious ideology is the product of man's relations to nature and within his own society, we may assume that this ideology changed with the transformation of social relations. The fundamental step in this evolution was the rise of class society and, as a consequence, the formation of the state.[47] The hypothesis consists in proposing that, parallel to these sociopolitical processes, religion acquired a new function within class society. By means of this function the new power structures, based on new relations of production, became "mystified" in their true content.[48] It was the purpose of this mystification to make the social relations appear to be just, in terms of reciprocal relations as they had existed before in egalitarian segmental society, while, objectively, the new social system now came to be based upon the domination of one class over the rest of the population. Further, the control of religious activities became a prerogative of the priests, who were the representatives of—indeed, part of—the ruling class. That is, the ruler, the priests, and, to some extent, the ruling class as a whole, appear as the necessary intermediaries between the people on the one hand and agriculture, the cosmos, and the supernatural world on the other. The function of ideology is to legitimize these relations, which, in objective terms, result in the benefit of the ruling class. While the common people give tribute in labor and material goods to the nobles, the latter return to the common people ideological goods: just government, prosperity of society, success in warfare, fertility of the crops, and the orderly functioning of the universe.

If we analyze the place of astronomy within this context, we can realize its extraordinary ideological importance. Since astronomical and calendrical sciences were based upon the observation of natural cycles and recurrent phenomena, they provided those who had access to this knowledge with the ability to give the appearance of controlling those phenomena and producing them deliberately. At certain significant dates, the calendar required the execution of ceremonies. These could only be performed by the priest-rulers, since they possessed the monopoly of the state cult. Although intimately related to agriculture, these ceremonies took place at the great pyramids that formed the center of the urban settlements, and were, at the same time, the territorial symbol of po-

litical power. Thus, the priest-rulers created the illusion that they were indispensable to the proper execution of the rites on which depended the recurrence of natural phenomena, the growing of maize and other food-plants, and the successful accomplishment of agricultural cycles. *Cult as social action produced a transference of associations that reversed the causal relationship and made natural phenomena appear to be a consequence of the proper performance of ritual.*

To what extent did this endeavor of the priests become their own obsession, or did they deliberately use it as an instrument of domination? In fact, both factors were intimately related. The foundation of the power of these priest-rulers resided precisely in the combination of their monopoly of astronomical observation and its application to the agricultural cycles; *thus, they simultaneously controlled important* aspects of social, economic, and political life.

What was the nature of this ruling class? How accurate is it to speak of a theocracy? Another comment by Paul Kirchhoff, preserved in his unedited notebooks, addresses these questions. According to this scholar,

> To understand the nature of theocracy, one has to make comparisons. The only theocracies that we know of are abortive conquest states that later retired to religion. One should be very careful with the term "theocracy." Its reflection is found in religious organization. The priests form part of the state apparatus. Within this capacity, they are full-time specialists. These specialists are able to obtain a status and hierarchy in the state organization according to the influence they exercise within the state as they have produced it.[49]

What transformations did this ruling class experience from the time of its rise in pre-Classic times to the Classic and the post-Classic? It seems that, initially, the legitimization of government was made entirely in religious terms. *Cosmovisión* and astronomy were fundamental in giving cohesion to the process of the formation of the state. Was the ideology of the equilibrium of natural forces and the pretension of the priest-rulers to guarantee this equilibrium by means of their cult an adequate expression of a real equilibrium that existed during Classic times in the socio-economic and political relations between the urban centers and the rural peasant comunities? In this case, we are thinking, above all, of the great metropolis of Teotihuacan and its "empire." Was the breaking up of this equilibrium the main cause of the cataclysm of the Classic cultures?

With the rise of a military ruling class during the Post-Classic age, in

what way did the elements of this *cosmovisión* change, and were any alternatives to this explanation of the cosmos developed? With respect to this point we also ask ourselves, How far had this ideology initially been a driving force for socioeconomic and political evolution, and from which particular moment might it have converted itself into a "conservative ideology," an instrument for maintaining in power a ruling class that hindered the transformation of society beyond the material limits it had reached? Or, to put it in other terms, to what extent were the same "forms" and "structures" maintained during later periods, while their "function" changed within the ideology of that society?

These questions equally apply to the role that astronomy played within society throughout Mesoamerican history. Naturally, ethnohistorical documents only give ample testimony of conditions on the eve of the Conquest and for earlier periods we have to rely on archaeological and iconographic sources. Unfortunately, only too few pre-Hispanic codices have survived destruction by the Spaniards after the Conquest. However, the importance of astronomy has been established beyond any doubt from the interdisciplinary research undertaken in the last few years in the field of archaeoastronomy. The preceding considerations on the interrelationship between astronomy, *cosmovisión*, and society have raised more questions than can be answered at present; perhaps they can contribute to the development of further lines of research on the complex and fascinating ways in which pre-Hispanic man perceived the world and cosmos that surrounded him.

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2. I became interested in this subject quite some years ago when, from the point of view of my research on Aztec religion, I became aware of the need to know more about the astronomical dimensions of Aztec calendrics and cult matters. Earlier authors—Seler,

Beyer, Lehmann, etc. – naturally influenced me in my interests, but I am especially indebted to K. A. Nowotny and Paul Kirchhoff, and, more recently, to A. Aveni, H. Hartung, and F. Tichy. I owe very much to Franz Tichy's studies of the orientation of Mexican pyramids, in which he combines cultural geography and astronomy with an ethnohistorical study of the Mesoamerican calendar. His recent research shares much with Kirchhoff's approach to the study of pre-Hispanic chronology, and, in a way, can be considered its fruitful continuation.

3. See AVENI,[1] *Skywatchers*; JOHANNA BRODA, "The Mexican Calendar," *Acta Ethnologica et Linguistica*, no. 25 (Vienna: 1969); ALFONSO CASO, *Los Calendarios Prehispánicos* (México: Universidad Nacional Autónoma de México, 1967).

4. See VINCENT H. MALMSTROM, "Origin of the Mesoamerican 260-Day Calendar," *Science*, vol. 181 (1973), pp. 939–41; ROBERT H. MERRILL, "Maya Sun Calendar Dictum Disproved," *American Antiquity*, vol. 10 (1945), pp. 307–11; ZELIA NUTTALL, "La Observación del Paso del Sol por el Zenit por los Antiguos Habitantes de la América Tropical," *Publicaciones de la Secretaría de Educación Pública*, vol. 17 (Mexico: 1928), no. 20.

5. See the *Dresden Codex*; for an excellent synthesis of the interpretation of the astronomical contents of this unique pre-Hispanic codex, see AVENI,[1] *Skywatchers*, pp. 161–83.

6. EUGENE G. DURSIN, "Orientations of Mesoamerican Structures: A Study in Astro-Archaeology," M.A. Thesis, Universidad de las Américas, Puebla, México (1968); ROBERT H. FUSON, "The Orientation of Mayan Ceremonial Centers," *Association of American Geographers, Annals*, vol. 59 (1969), pp. 494–511; GEORGE KUBLER, "La Traza Colonial de Cholula," *Estudios de Historia Novohispana*, vol. 2 (1967), pp. 111–27; IGNACIO MARQUINA, "Algunas Consideraciones Acerca de la Orientación de los Monumentos Arquelógicos de México," *Boletín INAH*, series 2, vol. 19 (Mexico: INAH, 1976), p. 59, *Arquitectura Prehispánica* (México: INAH, 1964); MERRILL;[4] NUTTALL;[4] O.G. RICKETSON, "Astronomical Observatories in the Maya Area," *Geographical Review*, vol. 18 (1928), pp. 215–25; "Uaxactún, Guatemala, Group E, 1926–31," *Carnegie Institution of Washington Publications*, no. 477 (1937).

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9. Kubler,[6] p. 116.

10. Tichy,[8] "Ordnung," p. 123.

11. In the latitude of Cholula (19° 3′), the sun reaches the altitude of 94.5° on the meridian of the southern horizon, which means that it moves 4.5° north of the altitude of the zenith. This fact is very interesting, since, according to Tichy, 4.5° was the pre-Hispanic unit used to divide the circle into 80 parts (Tichy,[8] "Ordnung," pp. 128–29). These and several other calendrical reasons suggest that the location of Cholula might have been selected on the basis of cosmological considerations. The same might apply to Malinalco and Xochicalco, which both have practically the same latitude as Cholula. It has also been suggested that the latitude of Copán, Honduras might have been deliberately selected for calendrical reasons (see Malmstrom[4]).

12. Ricketson;[6] Tichy,[8] "Ordnung," fig. 10.

13. Tichy,[8] "Ordnung," p. 118.

14. Fuson,[6] p. 499.

15. Ulrich Köhler, "On the Significance of the Aztec Day Sign 'Olin,' " in *Time and Space in Ancient Mesoamerican Cosmovision*, ed. F. Tichy and A. F. Aveni (University of Erlangen-Nurenberg: in press).

16. Rafael Girard, *Los Mayos Eternos* (Mexico: Libro Mex., 1966).

17. See Köhler;[15] Alfonso Villa Rojas, "Los Conceptos de Espacio y Tiempo Entre los Grupos Mayances Contemporáneos," in *Tiempo y Realidad en el Pensamiento Maya. Ensayo de Acercamiento*, ed. M. Leon-Portilla (Mexico: Instituto de Investigaciones Históricas, serie Culturas Mesoamericanas 2, UNAM, 1968), pp. 119–67; Evon Z. Vogt, *Zinacantan. A Maya Community in the Highlands of Chiapas* (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1969).

18. See Tichy,[8] "Sonnenbeobachtungen."

19. Tichy,[8] "Sonnenbeobachtungen."

20. A population living at the northern limits of Teotihuacan civilization built a ceremonial site precisely at the Tropic of Cancer. This site, Alta Vista (Zacatecas), consisted of several constructions that specifically permitted the observation of the summer solstice, i.e., the zenith. It is impossible to overestimate the calendrical importance of this site, the location of which cannot but have been chosen deliberately. Therefore, the recent excavations and measurements undertaken by Kelley, Aveni, and Hartung at Alta Vista acquire a particular significance (Aveni *et al.*,[7] "Alta Vista").

21. See Pedro Carrasco, "Las Fiestas de los Meses Mexicanos," in *Mesoamerica: Homenaje al Doctor Paul Kirchhoff* (Mexico: SEP-INAH, 1979), pp. 51–60.

22. Tichy,[8] "Festkalender," pp. 129–34.

23. HARTUNG,[7] "Scheme," p. 194.
24. AVENI and HARTUNG,[7] TICHY,[8] "Festkalender," p. 131-32, "Sonnenbeobachtungen."
25. The aforementioned studies by Tichy and Aveni and Hartung[24] contain the first serious measurments and interpretations of the astronomical significance of the tube that have been made at Xochicalco. However, they did not take into consideration the fact that, although the center line of the tube is vertical, its northern side is slightly inclined to the south, which gives an orientation towards noon on the day of the summer solstice (private communication from Emilio Bejarano, director of the Centro Regional del INAH, Cuernavaca, Morelos, and personal observation on zenith and solstice days, May-June, 1980).
26. TICHY,[8] "Calendario," "Festkalender," "Ordnung," "Sonnenbeobachtungen."
27. The true length of the year could be observed not only by the zenith passages, but also by the recurrence of the position of certain stars and constellations. In this context, the heliacal risings were considered most important, particularly so the heliacal rising of the Pleiades (see JOHANNA BRODA, "La Fiesta Azteca del Fuego Nuevo y el Culto de las Pléyades," in *Time and Space in Ancient Mesoamerican Cosmovisión*, ed. F. Tichy and A. F. Aveni (University of Erlangen-Nurenberg; in press))
28. TICHY,[8] "Calendario," "Festkalender," "Ordnung," "Orientación," "Sonnenbeobachtungen."
29. Perhaps one should explore further the possibility that there existed different kinds of calendrical counts that functioned in a parallel way. The Vague Year of 365 days was a mathematical necessity for the calendrical system. However, an agricultural year in tune with the seasons was a practical necessity. The big question still remains, How would this "pragmatic" agricultural year have been coordinated with the rigid cycles of the calendar? A calendar correction of thirteen days every 52 years might have been a possibility; however, so far no proof for this or any other calendar correction has been found in the historical or archaeological record (see BRODA).[27]
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31. See CARRASCO.[21]
32. See JOHANNA BRODA, "Relaciones Políticas Ritualizadas: El Ritual como Expresión de una Ideología," in *Economía Política e Ideología en el México Prehispánico*, ed. P. Carrasco and J. Broda (Nueva Imagen-CISINAH, 1978), pp. 219-55.
33. FRAY FRANCISCO DE LAS NAVAS, *Calendario de Fray Francisco de las Navas, de Don Antonio de Guevara y Anónimo Tlaxcalteca*, manuscrito inédito, Colección Ramirez, Opúsculos Históricos, tomo 21, Colección Antigua, vol. 210, pp. 93-203 (Archivo Histórico del INAH, Mexico).
34. CARRASCO.[21]
35. See JOHANNA BRODA, "Tlacaxipehualiztli: A Reconstruction of an Aztec Calendar Festival from 16th Century Sources," *Revista Española de Antropología Americana*, vol. 5 (1970), pp. 197-274.
36. See BRODA.[27]
37. This table is based upon astronomical data provided in AVENI,[1] chap. 3. I would also like to acknowledge Aveni's personal communications on these points. A more detailed comment on this table can be found in BRODA,[27] and JOHANNA BRODA, "Ciclos Agricolas y Culto Mexica," unpublished.
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The Role of the Pleiades and of the Southern Cross and α and β Centauri in the Calendar of the Incas," this volume.

39. GARY URTON, *At the Crossroads of the Earth and the Sky: An Andean Cosmology*, Latin American Monographs (Austin: University of Texas Press, in press).

40. AVENI,[1] *Skywatchers*, p. 296.

41. BRODA.[27]

42. BRODA.[37]

43. BRODA,[27, 32, 35, 37] JOHANNA BRODA, "Cosmovisión y Estructuras de Poder en la Evolución Cultural Mesoamericana," *Comunicaciones, Simposio de la Fundación Alemana para la Investigación Científica*, vol. 15 (1978), pp. 165–72; "Los Estamentos en el Ceremonial Mexica," in *Estratificación Social en la Mesoamérica Prehispánica*, ed. P. Carrasco, J. Broda, *et al.* (México: SEP-INAH, 1976), pp. 37–66.

44. See WALTER LEHMANN, *Die Geschichte der Königreiche von Colhuacan und Mexiko*, *Quellenwerke zur Alten Geschichte Amerikas*, vol. 1 (Stuttgart-Berlin: Verlag Kohlhammer, 1938).

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The Zenith, the Mountain, the Center, and the Sea

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Most basic to Chamula spatial organization is the belief that they live at the center . . . 'the navel of the earth,' " Gary Gossen explains in his description of modern Tzotzil Maya cosmology.[1] He goes on to describe their belief that the vertical axis of the universe is associated with the north-south axis on the surface of the earth: north is equivalent to up and the sky, and south is the equivalent of down and the underworld.[1]

Independently, Gordon Brotherston and Dawn Ades came to the same conclusion about the cosmology of the 16th century Yucatecan Maya[2] and I have recently postulated that this same belief can be demonstrated for the Classic period Maya as well.[3] In this paper, I will suggest that this central cosmic axis governed the orientation and the iconographic program of pre-Classic Izapa, and that such a preoccupation with the zenith may have led to the creation of the 260-day ritual calendar at that site, as Malmstrom[4] suggested in 1973.

Izapa is in a region that was always noted for its rich volcanic soils and abundant agricultural production, especially of cacao; it is also located on a heavily traveled route that links nothern Mesoamerica with the south (FIGURE 1). There are more carved stelae at Izapa than at any other pre-Classic site (with the possible exception of Kaminaljuyu – which displayed no formal or thematic unity in its sculpture) and it has more carved monuments than most Classic Maya sites. There is no question that Izapa was an important center and that its role was qualitatively different from that of most contemporary sites.

Izapa is located on a latitude close to 15° N, which crosses the Pacific Ocean to the west and includes the post-Classic site of Mixco Viejo and

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FIGURE 1. Map of southern Maya regions, Pre-Classic period. Drawn by Barbara Page.

the Classic site of Copan to the east. V.H. Malmstrom has pointed out that only at this latitude is there a 260-day interval between the zenith days that bracket the movement of the sun into the southern hemisphere and, thus, the 260-day count may have originated at this latitude.[4] Malmstrom noted that, at Copan, Stelae 12 and 10 were erected to the east and west of the site, 7 km apart, on a line that marks sunset on the day that falls midway between the equinoxes and Copan zenith passages.[5] These monuments serve to announce the time for burning and planting, which is followed by the rains, and to signal the end of the rains, testifying to the practical importance of the zenith dates at Copan. Stelae 12 and 10 also have hieroglyphic inscriptions with dates in the Long Count that integrate them into the history of the site, thus involving these markers in celestial, agricultural, and dynastic cycles, or phases, at Copan.

At the latitude of Izapa and Copan, the 260-day period when the sun journeyed into the south may, early in pre-Classic times, have dictated a special count; this could have proceeded concurrently with a solar one, but discontinuously. In this model, the less important 105 days of the year would either have had their own separate count, or, less likely, have not been counted at all. It is further postulated that if the 260-day count was the most important and sacred ritual one, then it would have been retained by southerners who moved to the north or west. They would have taken it with them, and, since it no longer described a true seasonal interval, they might have celebrated it for its own sake, continuously, as well as concurrently with the solar count. This could explain how a southern calendar was used in more northern latitudes. If the 260-day calendar did originate at this southern latitude, then Izapa is probably the site that was in charge of its promulgation late in the pre-Classic period.

The site of Izapa is orientated 21° east of true north (FIGURE 2) and its north-south axis is focused upon the large mountain called Tacana.[6] This is the westernmost volcano in the unbroken chain that stretches eastward along the Pacific coast into lower Central America. Some of the oldest Mesoamerican ritual of which we have any evidence involved an Old God who was represented as an incense burner and was practiced in the vicinity of volcanoes.[7] This Old God is thought to have been an ancient deity who lived inside the mountains where there was fire; the earliest censers depicting him were stone ones found at the central highland site of Cuicuilco in the shadow of the volcano that destroyed it in late pre-Classic times. In the Maya regions, this Old God was also depicted as a

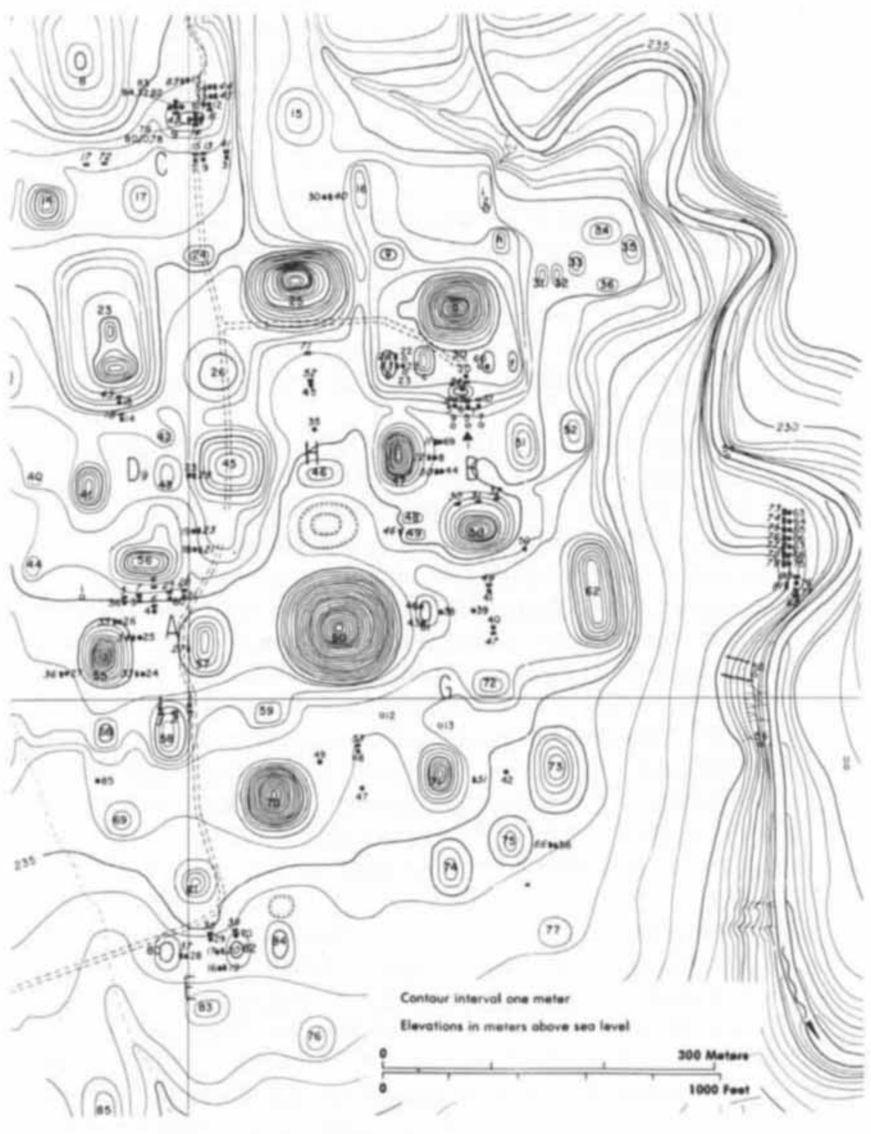

FIGURE 2. Map of the center of Izapa, Chiapas, Mexico, by Eduardo Mertinez E., 1962-64. Most Izapan monuments are plain, including the north-south row of stelae and altars next to the river on the east.

stone censer with the addition of the characteristics of the sun in the underworld[8] and, thus, of the sun when it was at the lowest point in its quadripartite diurnal journey: east, zenith, west, nadir (or underworld).

This symbolism of the sun and its association with volcanoes refers specifically to the vertical extremes of the sun's cycle and I suggest that the volcano Tacana was understood in the same way by the founders of Izapa; the volcano represented the axis that reached up into the sky and down into the underworld as did the sun in its journey. Visually, however, the mountain connoted both north and up, or the zenith. The site was laid out to conform to this cosmic axis and its stelae were carved to explain it. Both the site's organization and its iconographic program celebrate the zenith.

Rather than depict the vast volcano that linked the sky and earth, the Izapans adopted an imagery that was scaled to man. They conceived of an axial world tree with roots that metamorphosed into the earth crocodile and with branches that touched the sky, harboring singing birds, as on Stela 25 (FIGURE 3). This central tree, with subsidiary trees at the four compass points, were understood as the basic architecture of the cosmos throughout Maya history; they were illustrated in stone during the Classic period, in painted manuscripts during post-Classic times, and they were still described in the myths and incantations of the Colonial period.

At Izapa, the central axis was both anchored by the actual volcano Tacana and depicted as a tree in stelae dedicated to that axis. Best known of these is the complex Stela 5 (FIGURE 4), which represents a ceremony with a large cast of characters who perform their ritual tasks within the clearly designated boundaries of a sacred place. On the east and west, it is delimited by the highly stylized heads of a double-headed serpent; above, there is the characteristic Izapa sky band; and below (which denotes both the earth and the south), there is a place-locator panel with a watery band beneath it that serves to identify both the mythical waters of the underworld and those of the Pacific Ocean to the south.

Basic to an understanding of the underlying theme of Izapan monumental imagery are the three north-south axes at the center of the site (FIGURE 2). The central one (Group H) has the largest, longest plaza, with the site's biggest mounds at the north and south, but it has no carved monuments and it should probably be considered the primary central axis. To its east, Group B has a north-south axis on which there are carved stelae and a throne toward the north end; there are also carved stelae on

FIGURE 3. Stela 25, Izapa; north mound, Group A. After Norman,[9] by permission of the author and the New World Archaeological Foundation.

its west side, whereas the east side of the plaza is open for the purpose of viewing the eastern horizon. There are no carved stelae in front of the south mound.[9]

In the following discussion of the meaning of these monuments I am broadly in agreement with Garth Norman's recent work at the site, during which he measured azimuths in relation to the placement of the stelae.[10] Since one cannot be sure the monuments are in situ, I have assumed only that they are still in their original groups, and probably associated with their original mounds.

The symbolism of the central axis at Izapa has the same ramifications that Gossen found in his work with the modern Tzotzil; for them, the north is associated with the east, and together they have connotations of

FIGURE 4. Stela 5, Izapa; north mound, Group A. After Norman,[9] by permission of the author and the New World Archaeological Foundation.

rising and heat and good (and male). Conversely, the descending sun is western and southern with connotations of cold and evil (and female). When the priestly celebrants of Chamula make a circuit of their plaza it follows a counterclockwise path that is also that of the sun.[11] Norman has suggested that such a circuit might have been followed at ancient Izapa,[12] and I would only add that the sculpture also conforms to this axial symbolism.

In the eastern plaza, in Group B, Norman has noted that the stelae tend to have rising themes, although he did not include the most dramatic of these. This is Stela 11 (FIGURE 5), which depicts the bearded personified sun rising, flaming, arms outspread like wings, from the open jaws of the earth crocodile.[13]

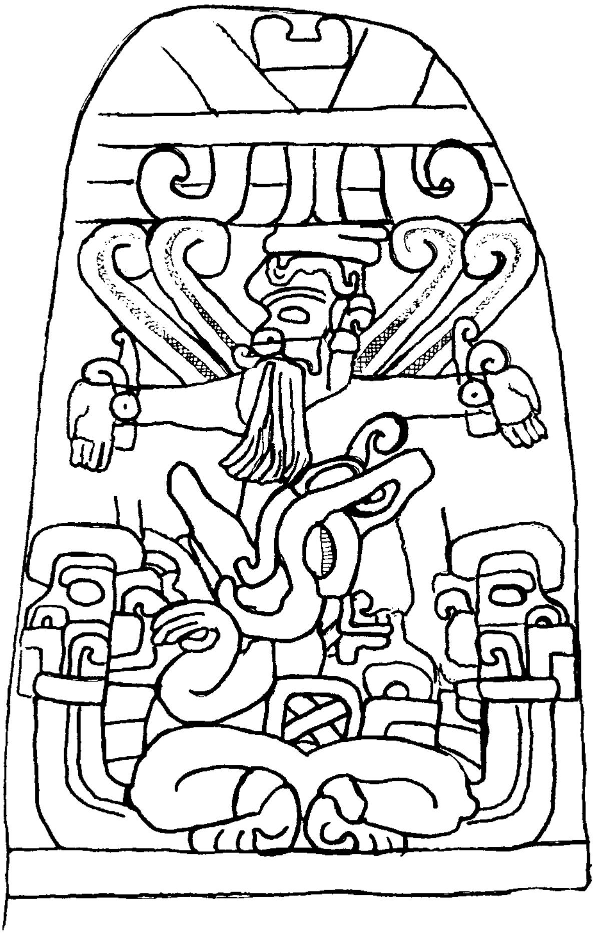

FIGURE 5. Stela 11, Izapa; west mound, Group B. After Norman,[9] by permission of the author and the New World Archaeological Foundation.

Following the ritual circuit north through the Group B plaza, then west and south into groups D and A, one encounters monuments with western descending themes; although, like the northern ones in Group B, the northern ones in Group A also have the quintessentially northern theme of the axial tree on Stelae 5 and 25 (FIGURES 3 and 4). Stela 25 is the most beautiful and poetic evocation of this theme at the site; it is a theme that is found seven or more centuries later, directly to the north at Palenque in the Temples of the Cross group.[14]

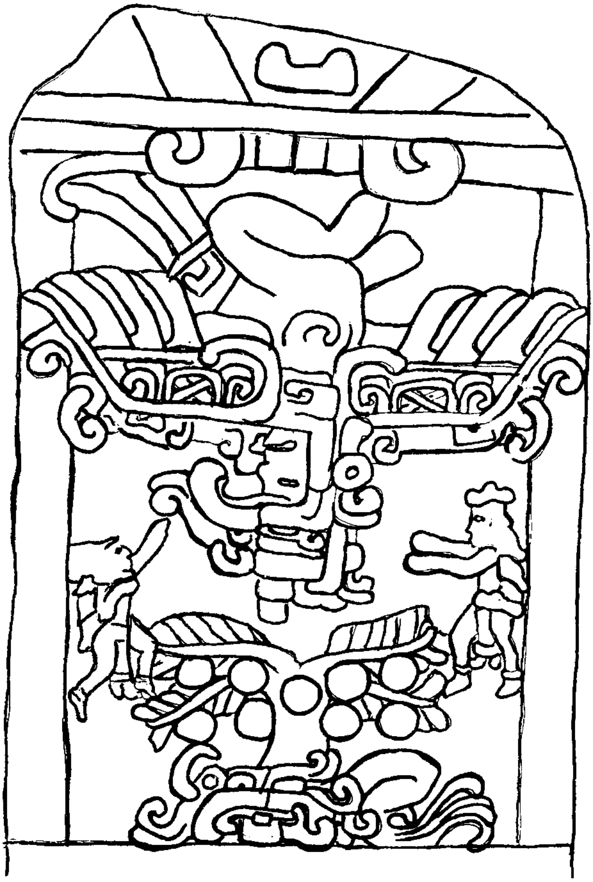

FIGURE 6. Stela 2, Izapa; south mound, Group A. After Norman,[9] by permission of the author and the New World Archaeological Foundation.

The most explicit descending images at Izapa are found on the north-south axis of the western A group. These include Stela 6 in the plaza, which depicts a "U-element" (the moon?) perhaps setting into the gaping jaws of a toad-earth monster,[15] and, on the south, Stela 2, with a winged anthropomorphic celestial body that descends from the sky into the branches of a fruit-laden axial tree with crocodilian roots (FIGURE 6).

Finally, Stela 4 (FIGURE 7), the northernmost axial monument in the western Group B, conforms to the northern and the western symbolism, but it also points to a change in monumental iconography at the site and

FIGURE 7. Stela 4, Izapa; north mound, Group A. After Norman,[9] by permission of the author and the New World Archaeological Foundation.

to the style that is generally considered antecedent to that of the Classic Maya. On Stela 4, a heavily-costumed striding man brandishes a throwing stick while a winged, anthropomorphic figure descends upon him from the sky. This is the kind of secular ruler figure, with deified (celestial) ancestor imagery, that is found in this style at Kaminaljuyu (Stela 11),[16] and, in a somewhat later, more Maya, style, with inscriptions, to the east at El Baul and Abaj Takalik,[17] and that is still the con-

vention in use early in the fifth century A.D. at Early Classic Tikal well to the north (Stelae 29 and 31).[18]

It is of particular interest that the imagery of the central axis was carefully observed at Tikal throughout its history; this was probably because Tikal's Late Pre-Classic ruling elite had come from the Pacific piedmont.[19] The imposing North Acropolis at Tikal was built, over many centuries, to house the tombs of the elite, and, in Early Classic times, the stelae of the rulers were lined up in front of this vast northern construction.[20] In the Late Classic period this symbolism was transferred to the twin pyramid groups; these were large square platforms with explicit directional significance, including identical pyramids on the east and west.[21] In these, the eastern pyramid and the northern position were associated with each other by the presence of stelae and altars in both places. However, the northern enclosure of the twin pyramid groups contained carved monuments that depicted the elaborately costumed ruler of Tikal on the stela and often a bound captive on the altar at his feet;[9] this northern enclosure was roofless, in evocation of the verticality of the north-south axis and the ascending relationship of the ruler to his ancestors in the sky.[22]

The symbolism of the center is certainly present at all Maya sites, but it was elaborated in many ways and treated with varying degrees of attention. The concept of the central axis does not explain all Maya site organization, nor does it explain all the stelae of Izapa, where the theme was first expressed pictorially in its metaphorical grandeur, but I do not think that any of the Izapan monuments contradicts this interpretation. I propose that Izapa was the guardian of the center and the place where the 260 sacred days were counted between the zenith passages when the sun was in complete harmony with the cosmic axis. I would further propose that the zenith was inextricably associated with the concept of rulership, with the north, and with the interrelated positional schema for the organization and ritual use of the ceremonial center of Izapa and later Maya sites.[23]

ACKNOWLEDGMENTS

Special thanks are due V. Garth Norman, whose unpublished master's thesis was of value in this study, and to Anthony Aveni, whose advice was, as always, essential and generous.

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9. Stela 89 was, however, recently found at the southeast corner of this plaza; V. G. Norman, "Izapa Sculpture: Text," *New World Archaeological Foundation Paper*, vol. 30 (1976), no. 2, pp. 162-64. This stela depicts a bound captive and, in its basal (southern) position relative to this plaza, represents the earliest example of the Classic Maya convention that places bound captives beneath the feet of the rulers on stelae.
10. Norman.[6]
11. Gossen,[1] pp. 34-35.
12. Norman,[6] pp. 51-55.
13. Norman,[9] pp. 112-13. Norman says that Stela 11 depicts a setting sun because the scrolls above the figure curl inward. Generally, however, celestial beings descend head first in Mesoamerica (Figures 6 and 7).
14. A. P. Maudslay, *Biologia Centrali Americana* (London: Porter and Dulau, 1889-1902), vol. 4, pls. 76, 81. It is unlikely to be coincidental that the only other monumental example of this world tree imagery is found at Palenque, which is over 300 km directly to the north—that is, on the same cosmic axis.
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22. I am grateful to J. Erik Simpson for this interpretation, which derives from his dissertation on Classic Maya divination ritual.

23. At Teotihuacan, where Cerro Gordo provides a northern focus analogous to Tacana, the zenith may have had comparable significance, but there is no evidence that the Teotihuacanos ever had a hieratic social organization like that of the Maya.

A General Consideration of the Maya Correlation Question

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THE MAYA AND WESTERN perceptions of time stand in sharp contrast in their conceptions of its progression and of its character. Popular western culture views time as a mechanical interlocking of calendric cycles much like gears in a clock. The nature of western time itself reflects this view. Time advances as an endless, linear progression of days. The character of time for the Maya, on the other hand, was both animated and cyclical. The full-figure glyphs in Maya hieroglyphic writing portray the deities carrying units of time on their backs. The personality of the deity strongly influenced the divination for his temporal burden, lending the days either good or ill fortune. Maya time was also cyclical, producing a repetition of the same day in earlier and later periods. Believing that the events of a day were related to its position in the calendar, Maya priests divined the future by examining the history of that day in a previous cycle.

For these reasons, the perception and character of time were radically different in each culture. In the Maya world, time was the very substance of life rather than merely a measure of the events that took place within it. In the sixteenth century, these two perceptions were juxtaposed with the advent of the Spanish Conquest. The correlation of one calendrical system with the other, however, remains the subject of debate.

In 1556, Bishop Landa recorded that the day 12 Kan 1 Pop according to Yucatecan calendars was July 16, 1553 (Old Style).[1] Since that time, several attempts have been made to fit the Western calendar to that of the Maya. Specifically, Mayanists have searched for a single conversion

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factor that could be added to a Maya date to yield the Julian day equivalent. That constant was the Julian day number of 13.0.0.0.0 4 Ahau 8 Cumku, the beginning point of the Maya calendar. Astronomical, ethnohistorical, and archaeological evidence have been employed to arrive at possible correlations. To date, however, there has been no single clear solution of the correlation question that has satisfied all the evidence. Indeed, this may be impossible, given the inconsistencies in the data.

Kelley offered a thorough comparison and evaluation of the proposed correlations.[2] For this reason, the relative merits of individual correlations will not be discussed. Instead, this paper will examine the problem on a more general level. It will focus on the assumptions underlying the work performed, the use of the data in these cases and other possible assumptions now largely neglected. The motivation for this paper came from a growing sense that, after a long period of relatively uncritical acceptance of Thompson's third correlation (correlation constant = 584,283), the question remains unresolved. It is hoped that this paper can contribute to the further study of the correlation question by suggesting new kinds of solutions not allowed by the current framework of assumptions.

Several problems beset the search for a correlation. First, Maya chronology employed three distinct calendars instead of one. The Long Count tallied the total number of days from the starting date of 13.0.0.0.0 4 Ahau 8 Cumku. The 260-day count, or *tzolkin,* was used for divination and was composed of a systematic combination of 13 day numbers and 20 day names. The *haab,* or 365-day count, contained eighteen months of twenty days plus a 5-day month in order to approximate the tropical year. Second, the cyclic nature of Maya time made the search for a correlation more difficult. Maya calendars yielded a variety of similarly named days interspersed evenly over time as opposed to a unique series of days. By the time of the Conquest, the Long Count had fallen into desuetude, leaving only the 260- and 365-day counts. For this reason, ethnohistorical references to a day such as 11 Ahau 8 Zotz could be assigned any one of several positions at 52-year intervals. This fact introduced a great deal of ambiguity into already fragmentary and often conflicting data. Other problems that complicated the search for a correlation included the debate over: (1) intercalation, or the interjection and subtraction of days for the purpose of regulating several calendrical cycles together, (2) the observed or computed basis of the lunar series, (3) the lunar position from which the coefficient of Glyph D was reckoned – either the visible old moon day, the conjunction with the sun,

or the visible new moon day, and (4) the nature of the dates found in the Dresden Codex Venus and lunar tables.

A brief review of the three sources of data brought to bear on the problem will preface the discussion. First, astronomical data included the lunar series texts, which usually occur following a Long Count notation on monuments and occasionally on ceramic vessels. The information conveyed in each passage linked a specific Long Count date to the position of the moon. There are at least 250 such passages found as far north as Chichén Itzá and as far south as Copán, with the majority occurring at the southern sites. These, however, are not as conclusive as they would appear. Thompson noted that, both within and between sites, the lunar positions given are often inconsistent.[3] For example, at Pusilha, stelae O and P record different moon ages for the date 9.7.0.0.0 7 Ahau 3 Kankin.

The distances between moon ages were also frequently inconsistent. At this point, the debate between computed and observed lunar series numbers compounded the correlation problem. That is, the numbers recorded in the lunar texts may have been the product of calculations that were not perfectly commensurate with the lunar synodic period. The numbers inscribed would then vary slightly from observations and would require minor corrections to retain even an approximate fit to reality. Satterthwaite proposed a mixed record composed of both calculated and observed lunar ages.[4] Furthermore, he suggested that the lunation zero day may have shifted from visible new moon to conjunction day or, possibly, to visible old moon day.

The Venus table on Dresden pages 24 and 46–50 provided another key to the correlation question. The Long Count date 9.9.9.16.0 appearing on page 24 has been associated with a heliacal rising of Venus; the date 9.16.4.10.8 on page 51 has been linked to a point at or near a new moon by the inscriptions and the Dresden lunar table.[5] This same date may also have marked a nodal passage. On Santa Elena Poco Uinic stela 3, the date 9.17.19.13.16 5 Cib 14 Ch'en may have designated a new moon. This interpretation is supported by the text, which contained a kin glyph flanked by two "elbows," perhaps indicating a solar eclipse.[6]

The general approach implemented for interpreting astronomical data involves searching astronomical records for appropriate celestial events spaced at intervals commensurate with those found in the data. The astronomical approach alone, however, did not provide a solution. The information from the lunar series could not adequately anchor the correlation because of the inconsistencies. The other dates indicating a Venus position, a nodal passage of the sun, and a solar eclipse were sub-

ject to question about their interpretation and were too few in number to yield a decisive correlation. Finally, Willson attempted to pair the possible record of eclipses found on pages 51–58 of the Dresden Codex with actual eclipses.[7] He was unable to discover a series of eclipses spaced at the appropriate intervals and therefore failed to resolve the correlation question on that basis.

The most solid ethnohistorical evidence came from the writings of Landa.[8] Three statements have been especially relied upon in the search for a correlation. As mentioned above, he equated the day 12 Kan 1 Pop with July 16, 1553 (OS). He also recorded that the first year of Katun 11 Ahau was in 1541 at the time when the Spaniards first arrived in Merida. Finally, Landa wrote that two priests, Fathers Orbita and Fuensalida, reached Tayasal in 1618 during a Katun 3 Ahau. This statement was used to demonstrate a continuity with the Yucatec calendar, which was also counting a Katun 3 Ahau at that time. Later, Martinez discovered a statement in the Chilam Balam of Tizimin equating 11 Chuen 18 Zac and February 15, 1554.[9] The third source of ethnohistorical evidence came from the Chronicle of Oxkutzcab, which was translated from an earlier hieroglyphic text in 1685 by Don Juan Xiu.[10] On page 66 of the manuscript Morley demonstrated evidence that a Katun 13 Ahau ended in 1539.[11]

The Books of Chilam Balam also provided information, although often contradictory in nature. These transliterated versions of earlier hieroglyphic texts recorded Katun endings as shortened notations of the Long Count. Instead of giving every designation of a day, they simply gave the day name and number of the last day of the Katun. Thompson noted that the recopying of such texts may have resulted in some of the inconsistencies. In spite of these problems, Proskouriakoff found evidence of the tun count in the Books of Chilam Balam of Kaua and Perez.[12] Her work showed that the tun count fit with both the Chronicle of Oxkutzcab material and Landa's 12 Kan date. Finally, La Farge's ethnohistorical work in the Guatemalan Highlands demonstrated a uniformity in *tzolkin* count throughout the groups studied. In spite of this evidence for a "universal Sacred Round," La Farge noted several breaks in the *haab*, or year-count, among these groups.

The archaeological data relevant to the correlation question came largely from radiocarbon dates. Ceramic sequences were found to be too flexible to be of service in this case.[13] The work of Andrews in the Northern Yucatan,[14] however, demonstrated that radiocarbon dating did not resolve the correlation problem either. As summarized by Kubler, An-

drews found that the 12.9.0.0.0 correlation fit the northern archaeological material best, while the 11.16.0.0.0 correlation fit the southern material best.

Each of the three types of data presents a particular set of problems for interpretation. Common to all is a contradictory or ambiguous nature that allows each of the various correlations to claim some degree of support. In order to overcome the inadequacies of the individual lines of evidence, the solution, it seems, must rely on at least two, if not three, of the sources of data.

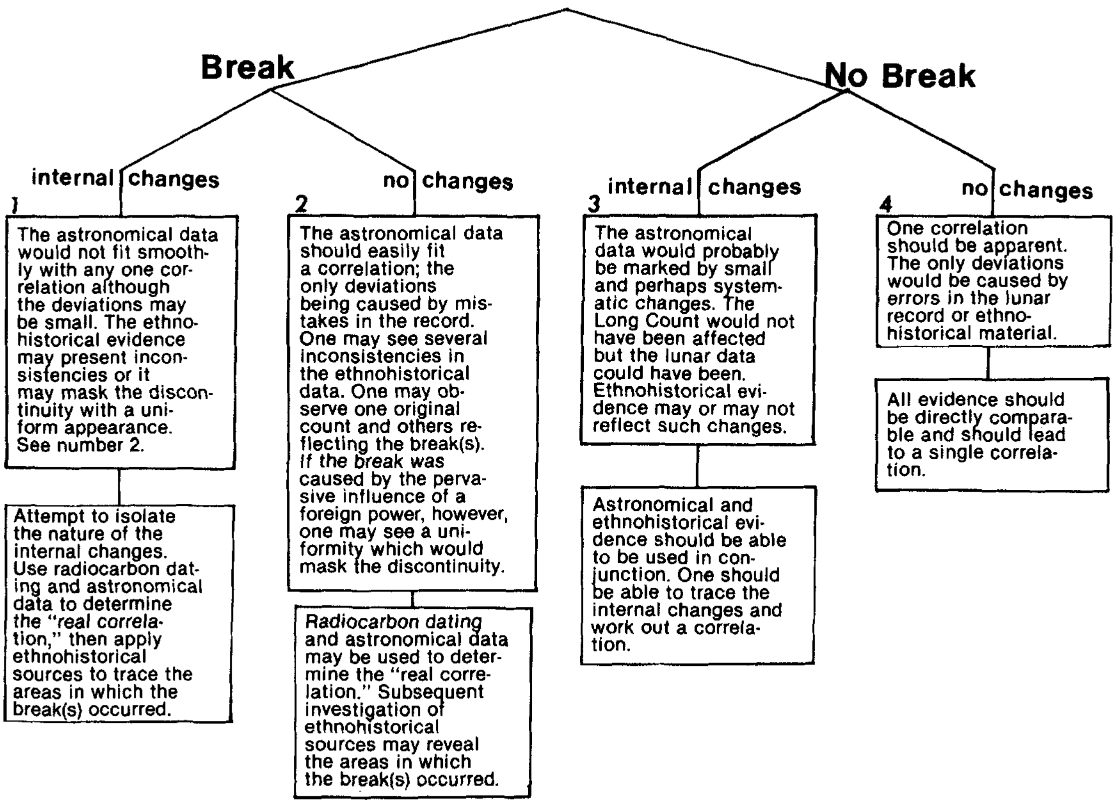
The assumptions heretofore governing the interpretation of these three kinds of data included the belief that there was a single correlation that would be applicable to all Maya dates. Inconsistencies in the data were, therefore, considered inaccuracies. Second, if one employs both the ethnohistorical data from the contact period and the astronomical and archaeological material from the Classic period, one must assume that the calendars were maintained unbroken. Finally, it has been assumed that a single correlation could be found for all three Maya counts. These a priori assumptions rule out intercalation or any shifts, breaks, or discontinuities in the calendrical system over the entire Maya area and through a period of several hundred years.

The lack of success of the above approach should lead to a reconsideration of the basic assumptions in order to more fully use and explain the data. Alternative assumptions will be explored and the logical possibilities stemming from their combination will be enumerated and briefly examined. FIGURE 1 graphically demonstrates the various combinations of assumptions possible.

The first alternative is to consider the possibility that more than one correlation is needed over the geographic extent of the Maya area. In this case, the data within a given region should be consistent, although one would expect sharp discontinuities across political or ecological boundaries. Kubler recommended that such an approach might provide the solution to "Andrews' Dilemma," or the conflicting evidence offered by radiocarbon dating.[15]

The second alternative is the possibility that the calendars were shifted either intentionally or accidentally between the Classic period and the arrival of the Spaniards. An intentional break may have been motivated by the desire to bring calendrical cycles back in line with the actual positions of the moon, Venus, or the sun. A break may also have occurred if the calendar was reinstituted after a period of disuse. The point at which the calendar was resumed, however, may or may not have been in phase

ONE CORRELATION IN THE CLASSIC PERIOD



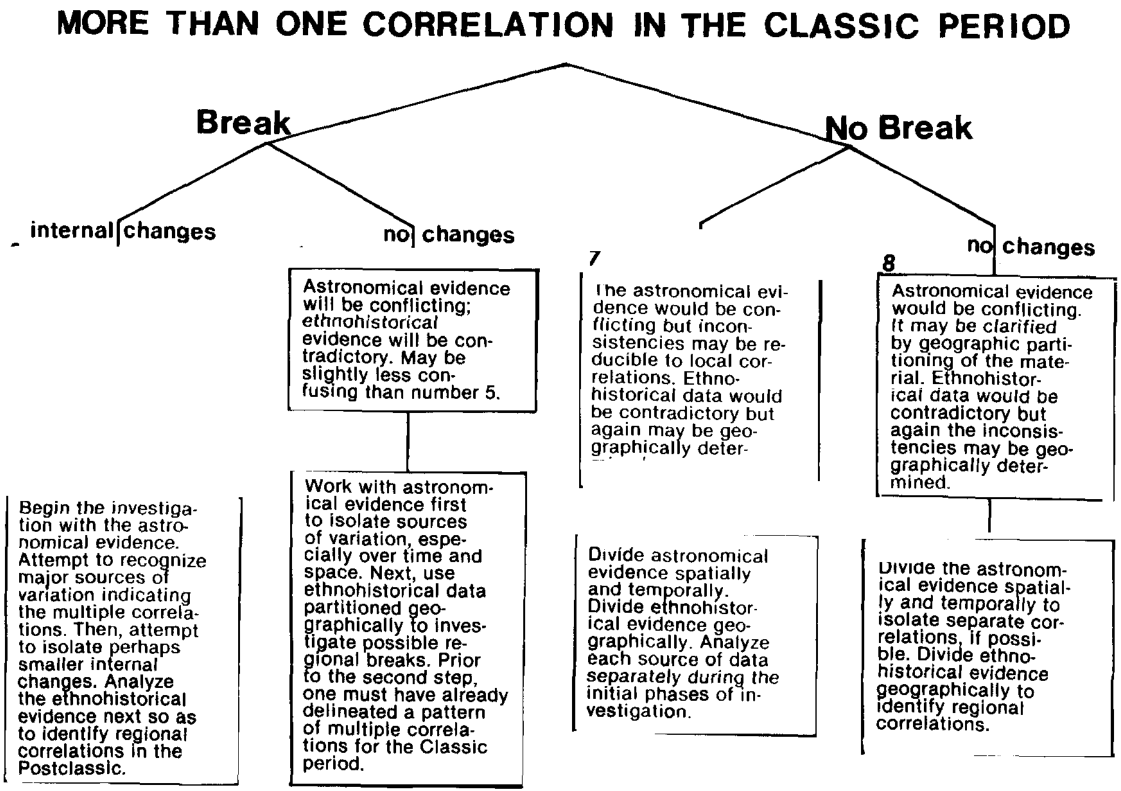


FIGURE 1. A decision tree of possible combinations of assumptions relating to the correlation of Maya and western calendrical systems.

with the original. Accidental shifts could have resulted from simple misuse, adding or dropping days in no particular pattern. It should be noted that each type of break would not necessarily cause a disjunction between the Classic period astronomical sources and the ethnohistorical ones. Finally, the three counts may not have been uniformly shifted or maintained. Indeed, the nature of each count may have determined the type of shift most likely, if the changes were intentional. For example, only the 365-day count may have been subject to intercalation because it alone was used to approximate the length of the tropical year. The shift in year bearers by one day provided a clear example of a calendrical disjunction in the Classic period.[16]

We are left, then, with a variety of possible changes that could have occurred in the Maya calendrical system. To summarize, shifts may have occurred over the geographic area, over the temporal span from the Classic to the Conquest period and within the elements of the system itself. In FIGURE 1, a decision tree illustrates the combinations of possible assumptions. The tree has three levels. On the first is the option of multiple correlations during the Classic period. The second level incorporates the possibility of a break in the calendar system after the Classic period. The third level distinguishes between the presence and absence of internal changes in the calendar system. Below each branch of the decision tree is a summary of the kind of data we might expect were those conditions an accurate description of reality. Finally, at the bottom of the table, there is a brief description of the research appropriate given each set of conditions.

Outlining the strategies proposed in FIGURE 1, it is suggested that one analyze data according to the geographic area from which they were drawn in order to resolve the problem of multiple correlations during the Classic period. If a break had occurred after the Classic period, one would have to limit the data at first to only astronomical and archaeological evidence. Once a correlation has been determined, the ethnohistorical sources may indicate in which areas breaks occurred. The problem of internal changes in the calendar is much more difficult to trace. We must be able to separate data reflecting different sets of changes so as to avoid confounding the astronomical evidence with a variety of discrete alterations. The Long Count and the Sacred Round were not connected to the astronomical realm and therefore probably were not subject to intentional or systematic changes. The *haab* and the lunar series, on the other hand, may have undergone small changes to regulate their cycles with other celestial periods.

The individual strategies do not place impossible limitations on the data base available. A combination of two or three, however, poses more serious restrictions. Only active use of the strategies will reveal the feasibility of partitioning the evidence in this way. By separating the data, we may also find that evidence previously considered incorrect may fit into a localized correlation. In any case, a lack of data should not determine the basic assumptions guiding the investigation. Rather, it should govern the data needed and direct further observation.

At stake in the correlation debate is not merely a technical solution that will aid in the chronological reconstruction of Maya history. The real importance of the problem lies in the potential it holds for a clearer understanding of the Maya perception of time. It may also serve to provide a clearer record of Maya history if multiple correlations reflect changes in political alignments. We know that, for the Maya, time and space were closely related. Indeed, the spatial necessarily implied the temporal and vice versa.[17] Marcus found evidence of a symbolic division of the Maya Lowlands into four political districts with regional capitals.[18] Perhaps there was an analogous discontinuity in calendrical systems marking similar political boundaries. Kubler speculated that such a shift in time might have marked a new era in Maya history, such as the founding of Chichén Itzá.[19]

Most importantly, we must resist viewing Maya time in the same way we view our own. The assumptions guiding work on the correlation question heretofore reflected a popular western perception of time as an immutable, uniform, and objective measurement. Time for the Maya was an ever-repeating cycle of events that progressed from day to day as burdens that the deities carried. We can, however, better approach the correlation question through a more complete understanding of the western calendar. Calendrical reforms such as those instituted by Pope Gregory XIII in 1582 demonstrate that far-reaching calendrical shifts mark even western timekeeping. A consideration of such reforms may provide a broader perspective from which to study the possibility of similar shifts implemented by the Maya. For these reasons, it may be well to thoroughly reconsider our assumptions in order to more fully understand Maya time and its relation to the Western calendrical system.

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paper. Final responsibility for its content rests, however, with the author.

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The Double-Headed Dragon and the Sky

A Pervasive Cosmological Symbol

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Senior among the scaled creatures,
Capable of occulation—capable of illumination,
Capable of slimness—capable of hugeness,
Capable of contraction—capable of extension,
It climbs to the sky at spring's division,
It plunges in the gulf at fall's division.

—A description of the Chinese dragon emphasizing "the essence of dragon nature as mutability of form" from the first century A.D. Chinese "Shu Wen" dictionary.[1]

THE BESTIARIES of the ancient world held many dragons. Though some were frightful fire-breathing monsters, most exhibited a decidedly benevolent character. Centuries of tangled lore and the mingling of diverse cultural traditions make it difficult to use the word dragon in an exact sense. Yet, in all contexts, the dragon is a fabulous beast—a great serpentine or saurian form possessing attributes of other creatures, including horns, wings, and feathers. For the present study, the term dragon will be used for a variety of mythical ophidian creatures of composite form, often possessing explicit avian characteristics.

Double-headed serpents or dragons form a rather specific subclass in the bestiary of mythical species. The term "two-headed dragon," or "bicephalic dragon," is common in the literature of pre-Columbian studies and refers to a sinuous form with a head at each end. These and related two-headed constructs—as opposed to such mythical entities as

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the Gorgon Medusa, the entwined serpents of the caduceus staff of Hermes, and the Hindu Naga diety, the great serpent with many heads—are the subject of this investigation. Cunningham has made a study of *Axial Bifurcation in Serpents* that shows that nature does occasionally produce remarkable two- and three-headed monstrous forms that may have inspired the Naga and related legends.[2] It is not suggested, however, that there exist genuine serpent monsters with a head at each end of the body.

The general term for such a two-headed, serpentine dragon figure is "amphisbaena," which derives from occidental mythologies. This preliminary study focuses on an assemblage of amphisbaenoid motifs and traditions that surround the Pacific basin, from the Makara dragons and other two-headed species of East Asia, to the Sisiutl of the Northwest Coast Indians, the two-headed "skyband" dragons of Mesoamerica, and the arching, two-headed serpent forms of the Andean cultures. The relationships between these distinct mythological and iconographic traditions are explored, and the many two-headed dragons are tentatively interpreted as related cosmological images representing the sky, the rainbow, and rain-bringing aspects of the sky.

THE AMPHISBAENA

The Amphisbaena is a legendary winged creature whose two heads enabled it to travel backwards or forwards with equal dexterity.[3] FIGURE 1 shows a medieval version of the Amphisbaena with wings, horn-like crests, and beards.[4] Amphisbaena lore is associated with the "encircling serpent" legends that describe a snake that rolls along like a hoop in either direction,[5] and is related to the Indian tradition that the world—heavens, earth in cosmic sea, and underworld—are all bound together by a great cosmic serpent grasping its tail. The name Amphisbaena has also been given to a certain genus of limbless lizards with a uniformity of thickness that makes it difficult to distinguish the head from the tail.

The great majority of references to the Amphisbaena characterize it as an evil, venomous, earthbound creature with the ability to strike from both ends. At the same time, however, some ancient sources attribute to it medicinal or therapeutic value as a remedy for chilblains, rheumatism, and for the healing of broken or dislocated bones.[5] In any event, the Amphisbaena lore that took root in Western culture[6] seems to be only distantly related to the benevolent rain, water, and fertility dragons of Asia.

FIGURE 1. The Amphisbaena. (From Rowland.[11])

THE MAKARA AND THE LUNG

In East Asia, the dragon is a cosmological creature associated with both the ridges and rills of the earth and the swirling, convoluted shapes of clouds in the sky. One of four supernatural creatures associated with the prime world-directions, the dragon is the animal of the East, of water, and of the color blue. Asian dragons are beneficent bringers of the crop-nourishing rains, but when the forces of nature are out of balance, they may become violent and destructive. Throughout Asia, the Thunder God is also a dragon whose writhing body causes the rumblings.

The Lung dragon of China is a symbol of rain and fertility.[7] Dwelling in water and in the sky, this dragon is a composite of avian and ophidian characteristics with wings and a body covered with the scales of a fish. It is well attested that the two-headed versions symbolize the rainbow.[7] Such rainbow representations appear on oracle-bone and jade carvings from the Shang and Chou periods. The jade pendant ornament from the Eastern Chou Period, 771–600 B.C., shown in FIGURE 6 is but one example. Furthermore, as Edward Schafer had demonstrated,

FIGURE 2a. A Makara head waterspout from Borobudur, Java. (From Bernet Kempers.[8])

FIGURE 2b. A drawing of a Makara head from the base of a temple doorway at Borobudur, Java. (From Covarrubias.[21])

> The old un-Indianized *lung* [dragon] . . . as the linguistic evidence shows, was accustomed to display himself—or herself—as the arch of the rainbow. . . . [A list of related] words, some monosyllabic, some bisyllabic, appear to be members of an archaic word family whose meaning combined "serpent" with "arch; vault." . . . Our Chinese dragon, then, is bent and curved like a bow and, like the surface of the sky dome itself, hovers over the aerial hemisphere. The dragon in its rainbow form was widely represented in the early art of south and east Asia. It was the *makara* of India which, like its Chinese counterpart in Han decorative art, appears as a rainbow emblem with a monstrous head at each extremity. The Chinese version, with outward facing heads, even influenced the figures assumed by sea and rain dragons in Javanese and Cambodian sculpture of the ninth century.[7]

The Makara, first among Hindu water monsters, has a crocodilian body, an elephant-like head, the ears of a bull, ram's horns, and a lion emerging from its mouth (see FIGURES 2, 3, and 4). The zodiacal sign of Capricorn, the sea-goat, has its ancestry in this creature. The examples il-

FIGURE 3a. A gateway in the wall of the fourth gallery main wall, north side, at Borobudur, Java. (From Bernet Kempers.[8])

lustrated span the doorways and niches of the great ninth-century Buddhist sanctuary of Borobudur in Java.[8] Kramrisch discusses such figures in the context of the Hindu temple, where they reside in celestial rivers and bear the river goddesses to earth:

> The Rivers have their sources and origin in heaven. Thence they descend to

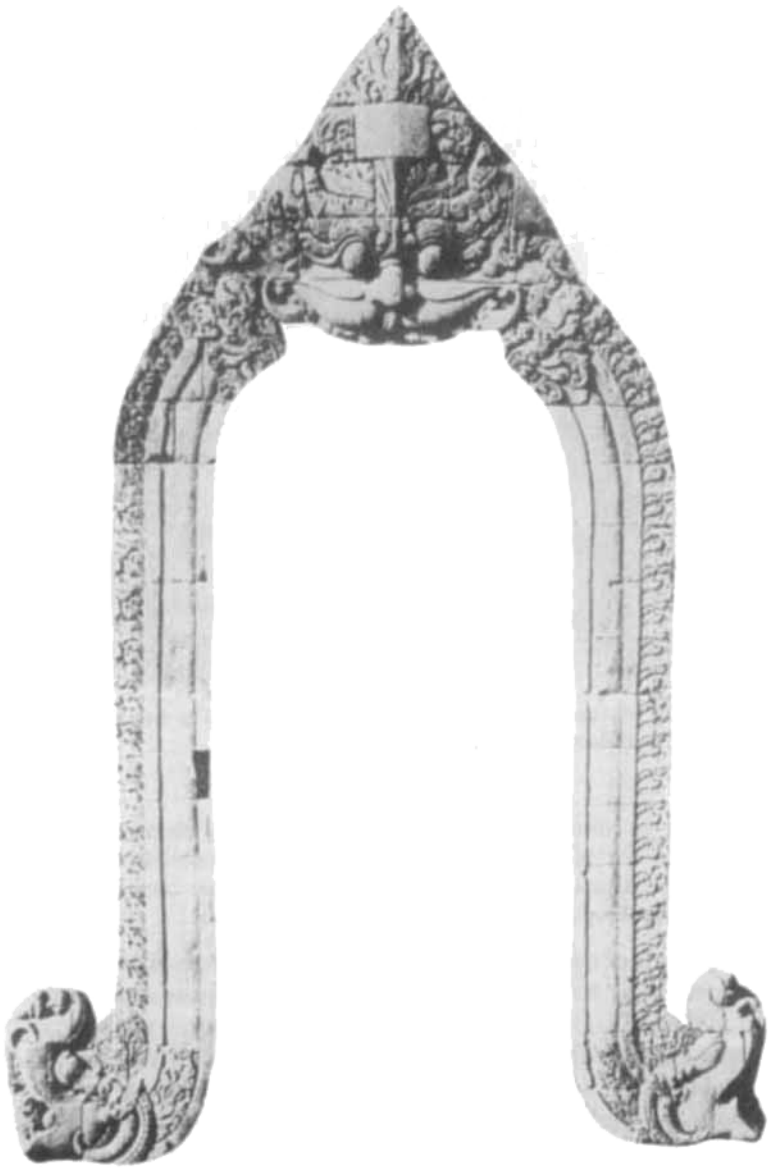

FIGURE 3b. A cutaway photograph of the gateway shown in FIGURE 3a.

FIGURE 4a. A photograph of a figure seated in a niche framed by two Makaras and the Face of Glory from Borobudur, Java. (From Shao.[22])

> earth. On the entrance of the early temples their images are carved to either side of the lintel. On its middle the image of the main divinity of the temple, and to either side of it those of other great Gods are carved. This then is the celestial region whence the rivers have descended. . . .[9]

The portals of the temple mark the place of the threshold to entry and initiation. They are surrounded by guardian divinities and symbols of entry and exit. To further establish the celestial context of the Makaras, we must examine the symbolism of the great mask on the lintel above, from which they descend.

Above the Makara doorways at Borobudur are the jawless masks of Kīrttimukha, the "Face of Glory" (see FIGURES 3 and 4). This is a composite creature with a lion's face having the aspects of ram, serpent, fish, bird, and man combined. The lion is a solar image, symbol of power and

FIGURE 4b. A drawing of the niche with seated figure from FIGURE 4a. (From Shao.[22])

radiance. In the Hindu tradition, the mask has further cosmological implications:

> The Face of Glory, the Kīrttimukha has thus three aspects. (1) It is the Death-head of Time (Kāla), the Devourer (grāsa), of Rāhu, the Eclipse. (2) Death's head is vested with the insignia of Ahi-Vrtra, the Dragon, the ophidian carrier and source of the solar power, the monster which envelops the universe and emits it. In this aspect the chinless, horned, fiery mask covers the reality 'Purusa', while (3) from its Lion's look and breath, the Supreme Spirit, Brahman goes out into the world. . . . The missing lower jaw is a more forcible representation than the open mouth, of out-breathing, sending forth, emitting the breath of life. Could the mouth be closed the progression of life would be at an end.[9]

FIGURE 5. Kwakiutl ceremonial curtain depicting the Sisiutl, ravens, rainbow, and copper. (From Goldman.[10])

This Face of Glory may combine with the Makaras that frequently issue from beneath its pouched lion cheeks to form the *Kāla-makara*, the full gateway to the temple.

The associations of the Makara with the rainbow, the descent of the celestial rivers, and the cosmic force of life and breath, the Face of Glory, are clearly established. They demonstrably incorporate the traditions of the Lung and other beneficent Asian rain dragons.

THE SISIUTL

The Indians of the Northwest Coast of America have in their mythology a powerful double-headed serpent/fish figure—a supernatural salmon. It is called the Sisiutl by the Kwakiutl tribe. The example shown in FIGURE 5 is described by Goldman as follows:

> A copper [symbol of wealth and prestige] is the centerpiece of the design, which also includes the double-headed serpent (sisiutl), a pair of flying ravens, and a rainbow made from two salmon arching downward from the head of the copper. The salmon heads rest against the two heads of the sisiutl who forms the base of the design. The bottom or body part of the cop-

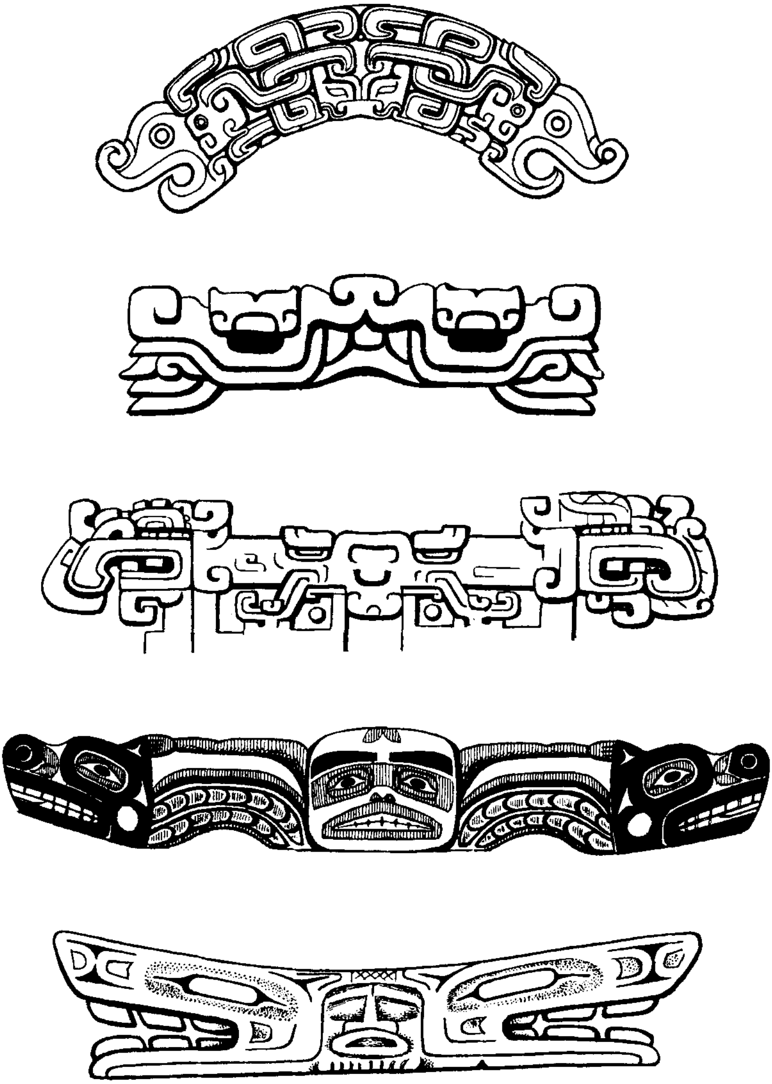

FIGURE 6. Five amphisbaenoid figures from Asia and the Americas. (From Covarrubias.[22]) From top to bottom: (a) Chinese Chou Period jade ornament, (b) mask from a Zapotec clay urn from Oaxaca, Mexico, (c) mask from a stela at El Mesón, Veracruz, Mexico, (d) a Kwakiutl Sisiutl carved ceremonial board, (e) a Kwakiutl carved ivory shaman's "soul-catcher."

> per rests upon the human head which is always the center of the sisiutl. . . .
>
> The Sisiutl, commonly thought of as a canoe, is the conveyor of the rainbow, the salmon, and the copper. That is to say, he is a bringer of light of the sky and of wealth of the sea.[10]

Goldman further characterizes the Sisiutl as "a blazing salmon" and as "as a lightning bolt that paralyzes and contorts people."[10] The form of the Sisiutl is often used by the Kwakiutl as a magical belt that "grants its wearer impregnability."

The double-headed horned Sisiutl with curled-up noses and central face and the related shamanic "soul-catcher" device are shown in FIGURE 6 in comparison with a Chinese Chou Period jade ornament and two representations from Mesoamerica. Visually, the Sisiutl is very similar to its Asian and American relatives. As a supernatural water creature, a magical canoe, and bearer of the rainbow, it is hypothetically related to the greater complex of celestial water dragons.

THE BICEPHALIC SKYBAND DRAGON

One of the principal and most ancient supernatural figures in Mesoamerican culture was the Feathered Serpent. Known as Quetzalcoatl among the Central Mexican civilizations and Kukulcan among the Maya, he was both a legendary culture hero, the wind god, a manifestation of the planet Venus at dawn, and a great plumed rattlesnake. *Caan* and *chan* in Maya languages are homonyms meaning both serpent and sky, and there are many representations of celestial dragons in Mesoamerican iconography. FIGURE 7 contains several examples, including the Aztec Fire Serpent (Xiucoatl), the Maya Bearded Dragon, and a two-headed version of the Maya Dragon with a figure emerging from one of its mouths. Two additional Mesoamerican examples of two-headed serpent forms with central masks (which may also be interpreted as alternating profile and frontal views) are shown in FIGURE 6.

The Maya bicephalic dragon is a particularly powerful image that often forms a frame or niche for a seated figure. FIGURE 8 shows three examples of this arching serpent form with a monster head at each end. It is now known that these scenes show Maya dynastic rulers seated in the niche of ancestral emergence, the center of their universe, which is spanned by the celestial dragon.[11] The emergence theme is further reinforced by the appearance of ancestral deities or personages in the open mouths of the dragon (see FIGURE 7a and c and FIGURE 8b and c). The bicephalic

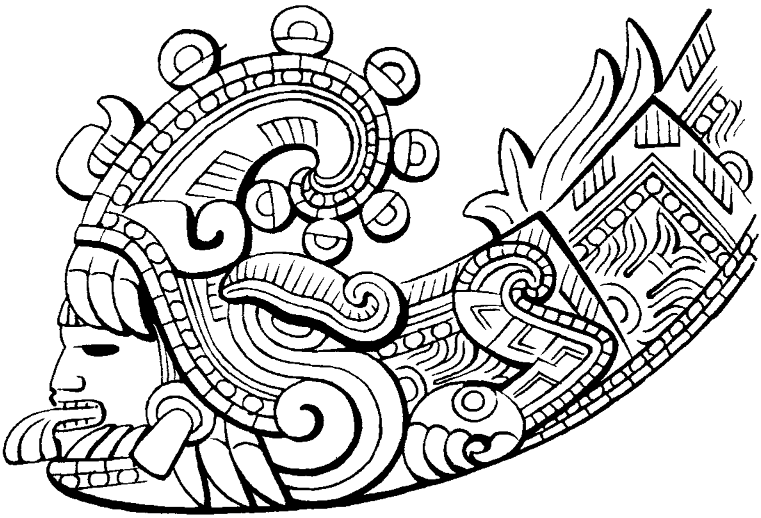

FIGURE 7a. A drawing of the head of an Aztec Fire Serpent (Xiucoatl) from the Stone of the Fifth Sun, Mexico City. (From Covarrubias.[21])

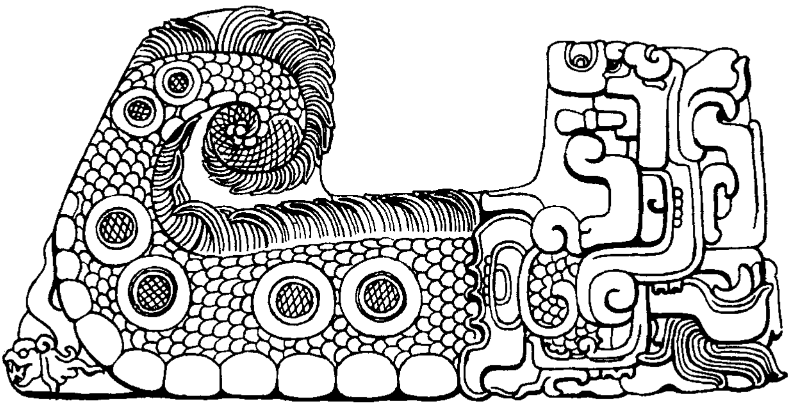

FIGURE 7b. A drawing of the Maya Bearded Dragon from Copan Altar O, Honduras. (From Covarrubias.[21])

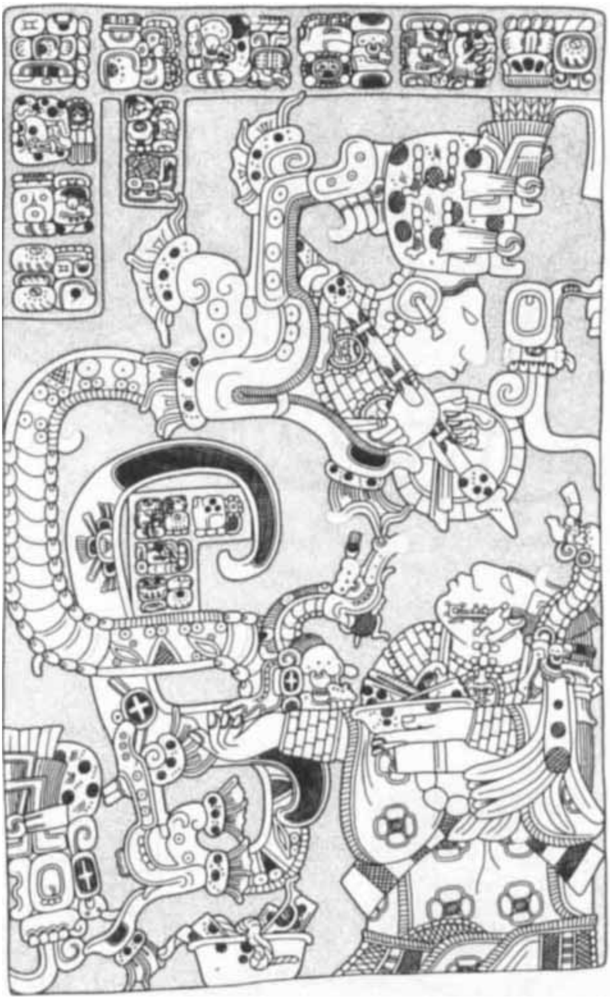

FIGURE 7c. A drawing of Lintel 25 from the Classic Maya site of Yaxchilan, which shows a two-headed dragon with a figure emerging from one mouth. (From Graham.[23])

dragon also becomes a scepter of cosmic authority held prominently by the ruler, as shown in examples from Copan (FIGURE 9).

FIGURE 8a shows a ruler at the Maya site of Quirigua seated in a niche created by the body of the bicephalic dragon. Perched on top is the frontal face of the "Serpent Bird," a companion composite deity also possess-

FIGURE 8a. A Maya figure seated in a two-headed skyband dragon niche on Quirigua Stela I, Guatemala. (From Shao.[22])

ing both avian and ophidian characteristics. The dragon's body is a band of hieroglyphic symbols. In abbreviated form these are known as "skybands," and they constitute the symbolic scales on the body of the celestial Maya dragon. The skyband elements are the celestial and terrestrial attributes of the dragon and companion Serpent Bird, and include symbols of the Sun, Moon, and Venus following their cyclical courses along the Dragon's body.[11]

To complement his cosmological aspect as a symbol of the sky, the bicephalic dragon is a rain-bringing fertilizing agent par excellence. It is a pan-Mesoamerican concept that the celestial water-bearers are of serpent form. The Maya Dresden Codex shows a beautiful example of the Skyband dragon, with pendent solar symbols, pouring water from his mouth onto the earth below (see FIGURE 10).

All in all, the cosmological, dynastic, and rain-bringing aspects of the two-headed dragons of Mesoamerica bear a remarkable resemblance to those of the Asian lung and Makara rainbow dragons.

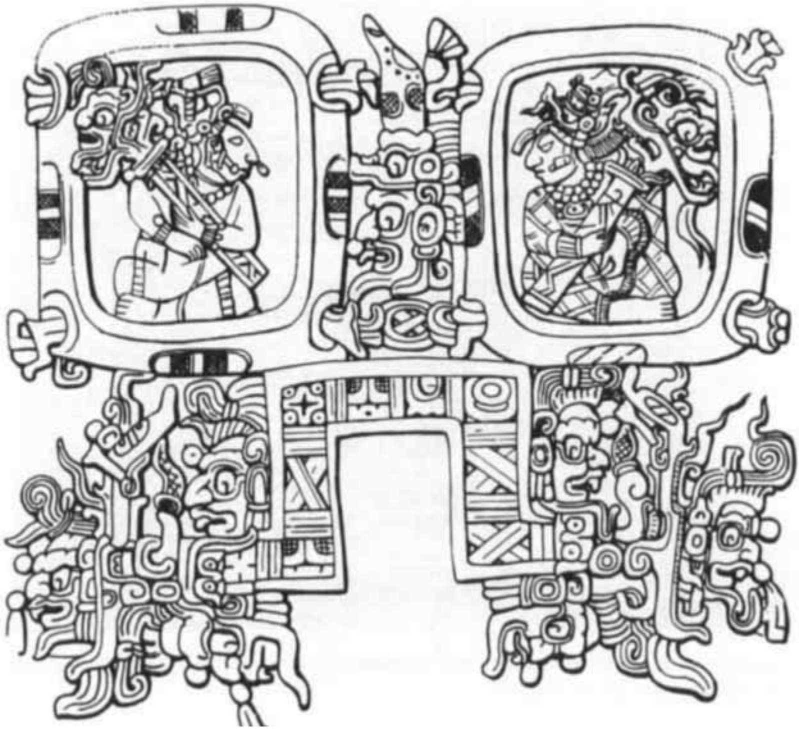

FIGURE 8b. A drawing of the top of Yaxchilan Stela 10, which shows a two-headed sky-band dragon with emergent deity heads. This image is a canopy for a standing Maya lord on the stela below (not shown). (From Spinden.[24])

THE ARCHING DOUBLE-HEADED DRAGONS OF THE ANDES

The iconography of the great ancient Andean cultures of Peru and Bolivia provides many examples of double-headed forms. From a period of over 2000 years from Chavín and the Early Horizon to the Late Horizon of the Inca empire, we find two-headed representations on ornaments, cloth, pottery, metalwork, and monumental relief. FIGURES 11, 12, and 13 show but a few examples. Though there are two-headed varieties of many creatures represented, on belts with "trophy heads," reed boats (FIGURE 11c), and litters (FIGURE 11a), it is the great arching serpent forms, such as those depicted in FIGURES 12 and 13, that are of primary interest.

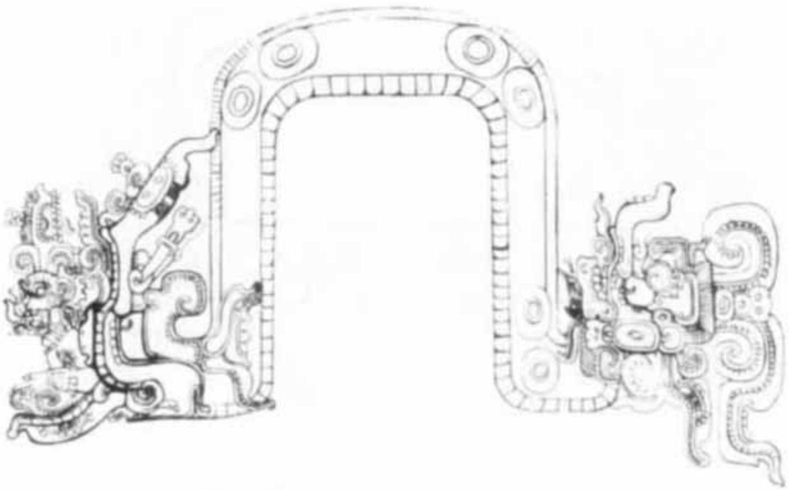

FIGURE 8c. A cutaway drawing of the two-headed dragon arching over a standing Maya lord (not shown) from Tikal Temple IV, Lintel 3. (From Shao.[22])

The cultures of the North Coast of Peru, in particular the Moche, Vicús, Loma Negra, and, later, the Chimú of Chanchán, exhibit the greatest frequency and continuity of arching serpent forms. All of the examples in FIGURES 11, 12, and 13 are from the Moche or contemporary Loma Negra cultures, save FIGURE 13b, a gold double-spout Chimú vessel (A.D. 1000–1250), and FIGURE 13c, a detail from the restored Huaca del Dragón at Chanchán (again from the Chimú culture).

The five scenes in FIGURE 12 show double-headed serpents arching over an anthropomorphic figure or head. FIGURE 12a, from a Moche stirrup-spout pot, shows a coca-chewing ceremony or event.[12] The double-banded serpent form has a feline or fox-like monster head at each end and is surrounded by dark circular dots. Kutscher and others have interpreted these dots as stars and the serpent as a symbol of the night sky.[13] The gold and turquoise bead from Loma Negra (FIGURE 12d) shows a figure surrounded by a double-headed dragon, which has become an element of the headdress. Here too, the circular forms may represent stars. The striking scene on the Moche pot in FIGURE 12e explicitly shows the serpent arching over the mountains with similar circular dots along the body.

It is a reasonable hypothesis that this arching dragon form is the sky or some celestial symbol. Larco Hoyle is among those scholars who have

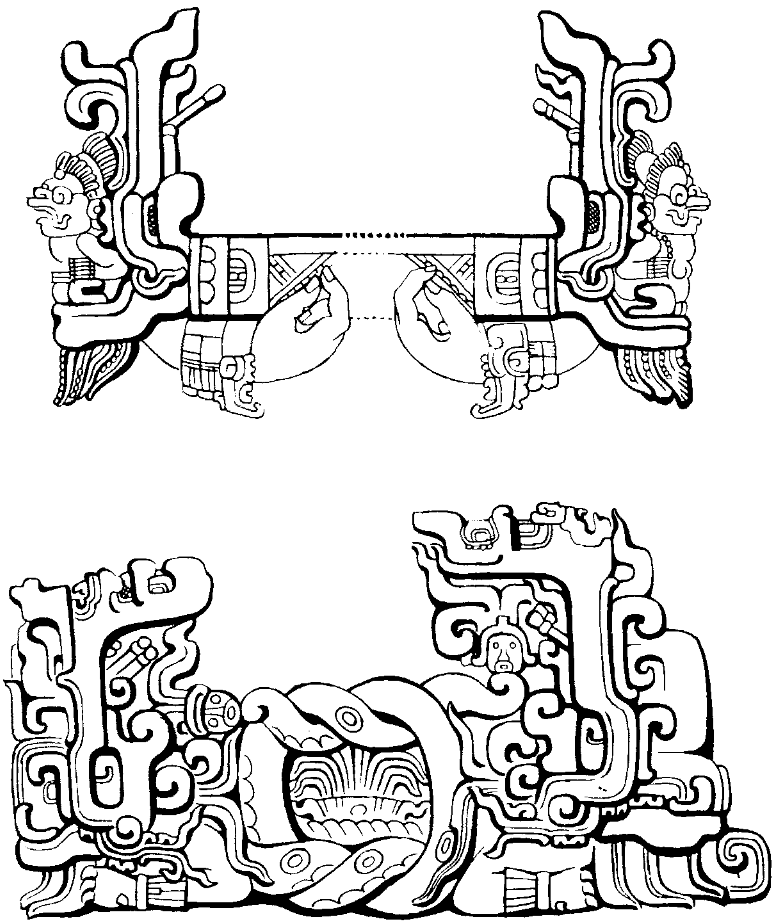

FIGURE 9. Top: A drawing of a Maya two-headed dragon ceremonial bar held by a ruler figure on Copan Stela N, Honduras. Bottom: A drawing of a Maya two-headed dragon ceremonial bar formed from interlaced dragons on Copan Altar O. (From Covarrubias.[21])

considered this sky serpent a water and fertility symbol—the rainbow—and have interpreted the dots as raindrops.[14] Anne-Louise Schaffer, in a recent study entitled "A Monster-Headed Complex of Mythical Creatures in the Loma Negra Metalwork," suggests that the sky serpent is a representation of the Milky Way.[15] This hypothesis gains considerable credibility in light of Gary Urton's ethnohistorical and ethnographic work in a Quechua-speaking Andean village, which suggests that the

FIGURE 10. A drawing of a Maya rain-bringing skyband dragon from Maya Dresden Codex p. 74. (From Villacorta and Villacorta.[25])

Milky Way, rainbows, and serpents are closely associated concepts both in the Andes and in the Amazon Basin.

Schaffer's study of the iconography of the corpus of Loma Negra metalwork showed that one ubiquitous monster head (e.g., see FIGURE 13a) could appear in any of three complexes of mythical creatures according to body type: serpentine, mammalian, and humanoid. The

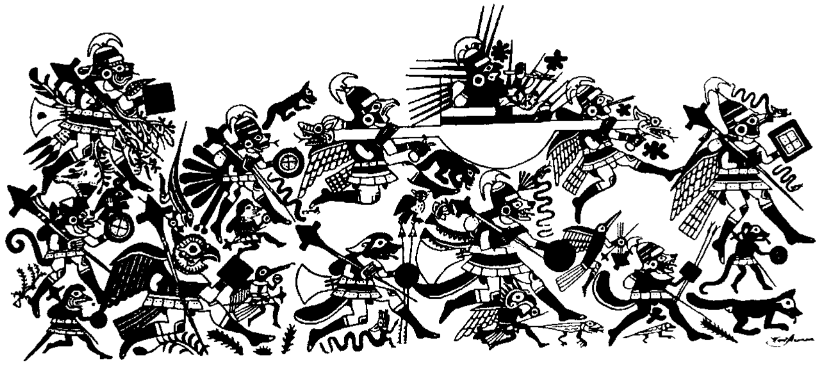

FIGURE 11a. A rollout drawing of a scene from a Moche stirrup-spout vessel. A supernatural figure with radiances is borne on a two-headed dragon litter. (From Kutscher.[26])

FIGURE 11b. A rollout drawing of a "presentation theme" scene with a two-headed dragon form from a Moche stirrup-spout vessel. (From Donnan.[16])

head is mammalian and resembles that of a fox, but it is quite clear that it is a composite creature with feline and perhaps serpentine characteristics.

This is essentially the same head that appears on the ends of the litter poles in what Donnan calls the "presentation theme" scenes[16] shown in FIGURES 11a and b. It is generally agreed that these scenes involve "supernaturals" and that the events may be taking place in the celestial realm.[17] A double-headed dragon with step motifs on its back divides the scene into two registers. Elizabeth Benson has suggested that this "celestial band" dragon indicates that the supernaturals involved may be planetary deities and that the events depicted are taking place in the sky.[17] The litters depicted in this scene (and in FIGURE 11a) would symbolically become celestial chariots bearing the individual represented to or

FIGURE 11c. A drawing of a two-headed dragon reed boat from a Moche vessel. (From Kutscher.[26])

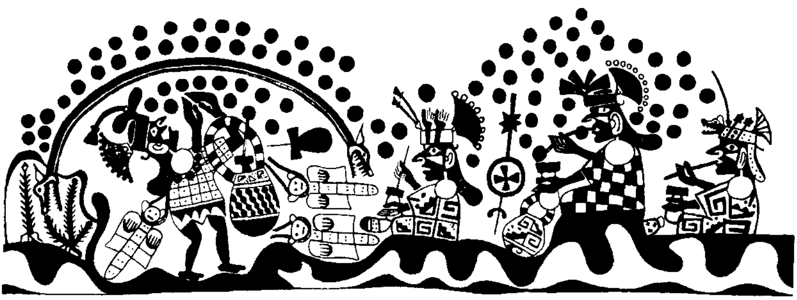

FIGURE 12a. A rollout drawing of a coca-taking scene with a two-headed dragon from a Moche stirrup-spout vessel. (From Donnan.[12])

through the heavenly realm. The arched double-spout jar shown in FIGURE 13b with step motifs and tenoned monster heads is an additional depiction of this celestial symbol.

Urton's dissertation research involved an ethnographic study entitled "The Astronomical System of a Community in the Peruvian Andes," which was called Misminay.[18] His discoveries regarding their systems

FIGURE 12b and c. A drawing of a two-headed dragon form arching over a standing figure taken from a Moche vessel. (From Kutscher.[26])

FIGURE 12d. Gold with turquoise inlay beads from Loma Negra showing a standing figure with a two-headed dragon apparently serving as the headdress. (From Lapiner.[27])

of folk classification and cosmology are relevant to the question of the identity of the arching dragons:

> Informants were unanimous on two points: rainbows are serpents (*amarus*) which rise out of springs (*pukius*) when it begins to rain. Since the Andean rainy season lasts for about six months (November-April), these multicolored, atmospheric serpents are associated with the rainy half of the annual cycle. In this connection, it is interesting to note that the Dark Cloud constellation called *Machácuay* ("serpent" . . .) is said to dominate the night sky during the rainy season. Thus, in the same season that the multicolored rainbow serpents are visible during the day time, the black serpent is visible at night.[18]

Machácuay is the Quechua name for the dark-cloud "serpent" constellation lying in the Milky Way—the *Mayu* or "River." In a recent publication entitled "Animals and Astronomy in the Quechua Universe," Urton further develops these connections between celestial serpents, rainbows, the dark clouds in the Milky Way, and the annual cycles of rainy and dry season, both in the Andes and in the Amazonian region.[13]

> *Amarus* are important for our study because the name is applied to rainbows which are believed to be giant serpents. The body of the Rainbow

FIGURE 12e. A drawing of a Moche vessel with a spotted two-headed dragon arching over a figure and mountains in the background. (From Kutscher.[26])

Serpent rises up out of one spring, arches through the sky, and buries the opposite end of its body in another spring. *Amarus* are thought of as double-headed; one head is buried in each spring. . . . The emergence of "meteorological" serpents (*amarus*) from the ground immediately following a rain shower, and their reentry as the atmosphere becomes less moist, is an important clue to understanding the relation between terrestrial and celestial reptiles in the Andes. The *amaru* which rises out of a spring after rain, exhibits a climatological behavior pattern similar to terrestrial serpents which, at the *end* of the cold/dry season and at the *beginning* of the warm/rainy season, emerge from subterranean hibernation. The Andean dry/cold season (May-July) is a period not only of reduced activity among reptilian fauna but also among the fauna upon which reptiles prey. Therefore, terrestrial reptiles in the Andes are variably active and inactive in direct relation to pronounced alternations between dry/cold and warm/rainy seasonal chances. . . . Since meteorological serpents (rain-

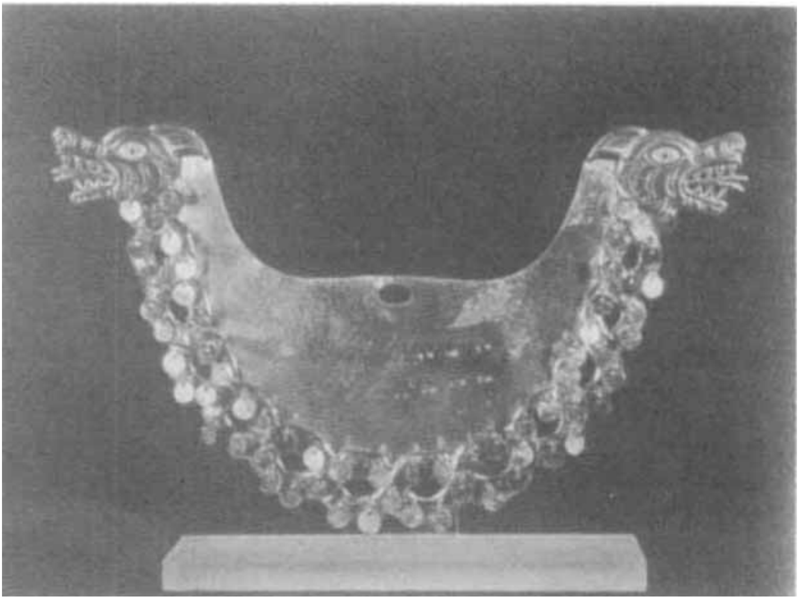

FIGURE 13a. A gold and silver nose ornament from Loma Negra showing the double-headed dragon. (From Lapiner.[27])

bows/*amarus*) only appear during the rainy part of the year, they exhibit a seasonal activity cycle similar to that of terrestrial reptiles.[19]

In his final analysis, Urton concludes that Andeans link the motions of the celestial serpent in the Milky Way with terrestrial serpents and their associations of water and fertility. The visible crossing back and forth of the Milky Way during the tropical year is also associated with the solstitial stations in June and December.[19] Urton cites further support from Lévi-Strauss in his studies of tropical forest astronomical symbolism, where patterns of relationships are created between the sun, rainbows, the Milky Way, and the Moon.[20]

In summary, these data strongly suggest that the arched, double-headed dragon forms of the Andes are celestial symbols probably related to serpents, rainbows, water, the Milky Way, and the yearly cycles of fertility. Here we have come full circle to the other motif complexes of the Americas and Asia. The similarities in these celestial representations and their associations are far more striking than their differences.

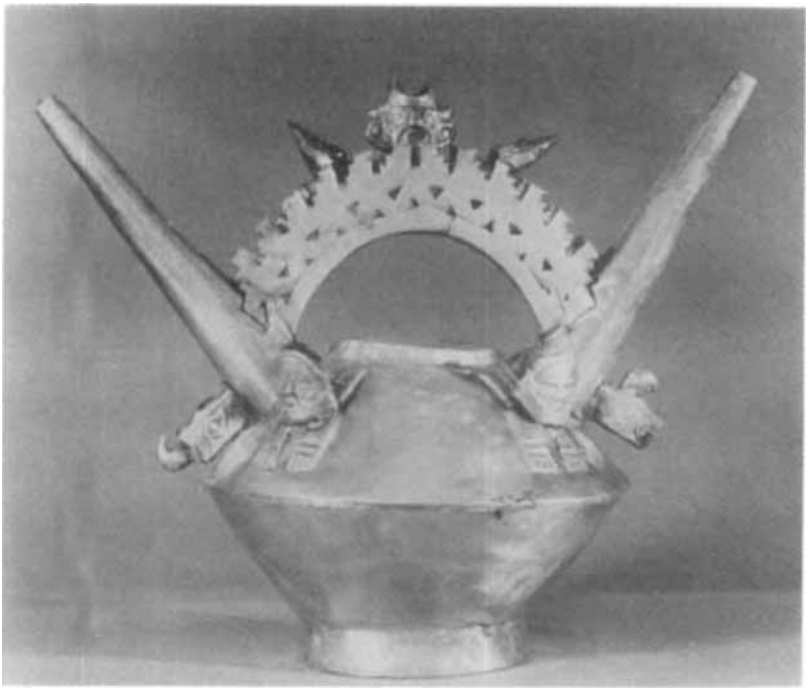

FIGURE 13b. A gold Chimú double-spout vessel with arching form and tenoned dragon heads. (From Lapiner.[27])

CONCLUSION

This preliminary investigation examined an assemblage of double-headed forms from cultures that surround the Pacific basin. From Asia to the Andes, these amphisbaenoid dragons are tentatively interpreted as related cosmological images that represent the sky (the zodiacal band or Milky Way), the rainbow, and the rain-bringing aspects of the sky. The pervasive Asiatic tradition is thought to have migrated into the Western Hemisphere along with those nomadic peoples whose progeny now populate the indigenous New World. The original mythological systems were subsequently modified and adapted to the needs of each specific culture according to the particular ecological circumstances. Geographical latitude (and hence the view of the sky) is one of these factors. It may well have been an important influence in the subsequent evolution of the celestial two-headed dragon myth and its iconographic manifestations.

FIGURE 13c. Adobe relief with arching two-headed dragons from the Chimú Huaca del Dragón at Chanchán. (From Anton.[28])

At low northern latitudes, the serpent-like band of the zodiac might have been a seasonally important, accessible sky metaphor for the Mesoamerican peoples, while the Milky Way "river," prominent in the southern sky, is a much more likely candidate for the dragon in the Andean and Amazonian cosmos. This is particularly compelling, since the annual motions of the Milky Way apparently synchronize with important periodic relationships in the natural environment.

The connections between the universals of sky, rainbow, water and fertility seem to be reasonably well established for the double-headed dragon complex. One further association is vital to our understanding of the extent and longevity of this *cosmovisión*. The arching form of the dragon creates a niche or portal to frame a human figure. The personages are divinities, deified mortals, or individual dynastic lords, as in the case of the Maya. With the cosmic dragon, symbol of celestial power and fertility, framing the scene, the individual would demonstrably become the center of his world and the Lord of Creation.

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Astronomical Models of Social Behavior Among Some Indians of Colombia

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AMONG MANY NATIVE tribes of Colombia, the tropical night sky and the cyclic motions of celestial bodies constitute models for certain forms of human behavior. The sky is seen as an enormous blueprint of everything that did, does, or will happen on the earth; an enormous map replete with information on every aspect of biological and cultural behavior, time, space, evolution, and psychological phenomena; in sum, an encyclopedic body of what one might call "survival information," the knowledge of which alone can give Man a measure of security.

The most obvious aspect is time, cyclic time. In Colombia, the yearly seasonal round is divided into four ninety-day periods that coincide with the beginnings and the ends of the two rainy and two dry seasons. Observation of the sun therefore becomes important for the management of natural resources. By this I refer not only to agriculture, but also to seasonal events, such as fish runs, bird migrations, the rutting and breeding seasons of different game animals, the various fruiting seasons of trees, and the cyclic availability of edible insects or mollusks, of honey, and of many other food resources. The precise prediction of the onset, progress, and end of each season is important not only to the horticulturalists, but also to the hunter and gatherer, to the prospective traveler, to the canoe builder, and to any group of people who intend to build a house.[1] Cyclic time, then, is observed by the natives on a scale that extends from hourly changes of physiological and psychological

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functioning and environmental changes in light, temperature, humidity, and so on, to changes in circadian rhythms, to monthly, seasonal, and yearly cycles, and, beyond that, even to the observation of equinoctical precession. Upon these cyclic phenomena of the heavens and of nature, the Indians project cycles of specific cultural relevance, such as the menstruation cycle, the cycle of embryonic development, the human life cycle, psychological developments, plant growth, and any number of other recurring events, as recognized by the natives.

Another aspect is space. Those facets of heavenly space that are of immediate importance to the Indians refer either to stable relationships, such as the outlines of certain constellations, or to dynamic relationships, such as those that exist between celestial bodies.[2] This refers mainly to the changing relationships between the sun, the moon, and the larger planets and to the changing position of the Milky Way. These fixed spaces and fixed orbits are very important to the Indians, who see in them a set of principles of order, of organization. For the same reason, any dissonance in this heavenly harmony is thought to be harmful. Eclipses, comets, meteorites, shooting stars, tektites, and planetary conjunctions are greatly feared, because they are thought to mirror calamitous conditions that exist somewhere on this earth. Dissonances do not predict coming events; instead, they point to malfunctionings that are actually taking place in human society or in nature. The observation of these celestial dysfunctions is thus a diagnostic procedure, not a prognostic one. Native astronomy is not much concerned with astrological prediction, but with learning to read the sky, which mirrors this world; the sky must be scrutinized in every detail because it is a map and a mirror of nature. What counts is the correct reading, because the sky is not only an ecological blueprint for Man's tenancy of this earth, but also a guide to spiritual development and moral integration.

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In the following I shall refer to three aboriginal cultures of Colombia: first, the Desana, a tribe of Tukanoan Indians of the equatorial rain forests of the Vaupés Territory in the Northwest Amazon;[3] second, the Kogi Indians of the Sierra Nevada de Santa Marta, in northern Colombia, at about 11° north;[4] and, third, the Muiska Indians of the Andean Highlands, at about 5° north.[5] The Desana and Kogi still number several thousands; the Muiska have disappeared and have become assimilated into the rural mestizo population, so that information on them is derived from archaeological remains and from the accounts of the early Spanish chroniclers.

I shall speak mainly of the equatorial Desana and their neighbors, and only briefly refer to the other tribes, to point out some similarities or differences. In Desana origin myths a frequent motif is the "search for the center," the "Center of the Day," as the Indians call it. In brief, the story is this: A supernatural hero who carries a staff goes in search of a spot where his staff, when standing upright, will not cast a shadow. He eventually locates this spot on the equatorial line, and it is there where he subsequently establishes his people. In one of many shamanic images, *the staff is said to be a shaft of sunlight, which, falling vertically into a* womb-like lake, fertilizes the earth. This idea of the "central point" is all-important to the Indians; it is, in essence, a spot where a cosmic sexual contact takes place, a meeting between Sky and Earth, and life on this earth subsequently develops in a bounded space that extends around this center.

The model for this bounded space is perceived in the sky. It consists of the huge hexagon formed by the stars Pollux, Procyon, Canopus, Achernar, T3 Eridani, and Capella. The center of this hexagon is said to be Epsilon Orionis, that is, the central star in Orion's belt.

Now, among the Desana and other Colombian Indians, hexagonal *shapes and outlines constitute fundamental ordering principles.*[6] *These* recurring shapes are observed, for example, in the hexagonal structure of rock crystals, which are common shamanistic power objects; they can be seen in honeycombs and wasp's nests, and in the hexagonal plates on the back of a tortoise shell. In the shamanist world view, all these hexagonal shapes are said to be imbued with transformative energies, and in this manner, all places, spots, and objects where a transformation is said to take place are imagined as hexagons, or as hexagonal containers. Thus, in shamanist imagery, the female womb is seen as a hexagonal body; the human brain is seen as a hexagon divided into innumerable hexagonal ventricles; and the structure of a house is imagined as a hexagon. All these hexagonal shapes symbolize continuity by transformation; they symbolize an eternally recurrent natural model that, by its unchanging persistence, expresses a sense of world order.

I have said that the model of bounded terrestrial space is seen in the sky, in the great hexagon of a number of bright stars centered upon Epsilon Orionis. Now, this celestial hexagon is projected upon the earth, where it delimits the tribal territories of the Tukanoan Indians. The image is that of an enormous transparent rock crystal standing upright, the six corners of which are the six stars I have mentioned, while, on earth, the corners are formed by six major waterfalls located on certain rivers (FIGURE 1). The center, the axis of this crystal tower, is a vertical line be-

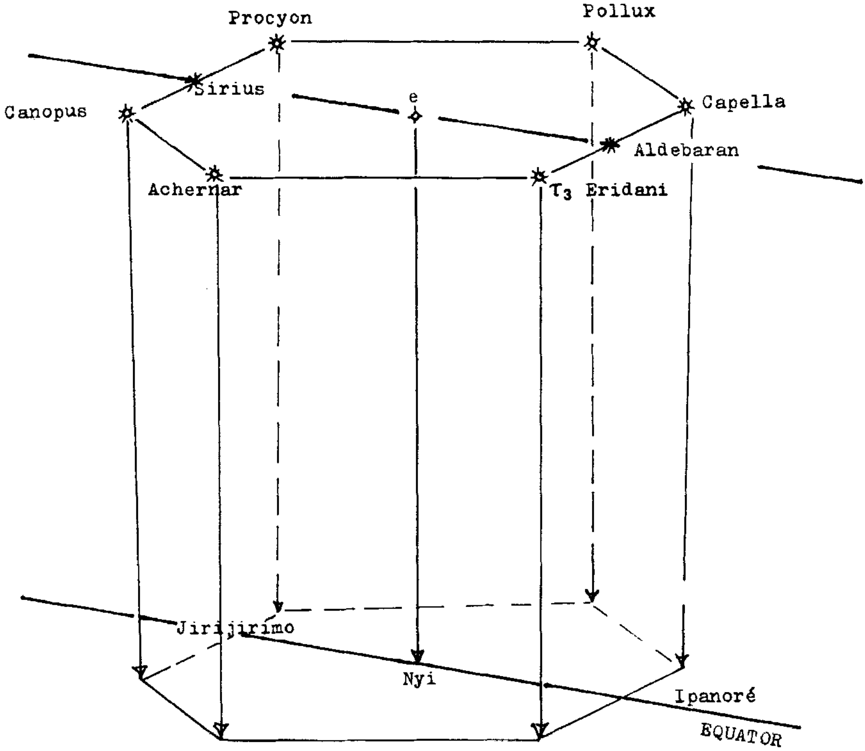

FIGURE 1. The hexagonal prism between sky and earth. The falls of Ipanoré are the point of origin of the tribe; the Jirijirimo falls are the largest in the entire territory; the other points correspond to minor falls. The center is the rock of Nyí, a large boulder covered with petroglyphs, located at the spot where the Pira-paraná crosses the equatorial line.

tween Epsilon Orionis and a large boulder covered with petroglyphs, located approximately at the spot where the equatorial line crosses a north-to-south flowing river.[7] In other words, the crystal axis is the phallic staff that joins the male sky to the female earth. Within this terrestrial hexagon all major celestial phenomena have their counterparts and mirror images. For example, the Vaupés river corresponds to the Milky Way; certain landmarks, such as isolated hills, lakes, or large rocks, are associated with stars or constellations, and Orion's belt is centered upon the equator, in an east-west direction.

According to the Desana and their neighbors, the twenty or so Tukanoan tribes are, ideally, grouped into six phratries, each one consisting of

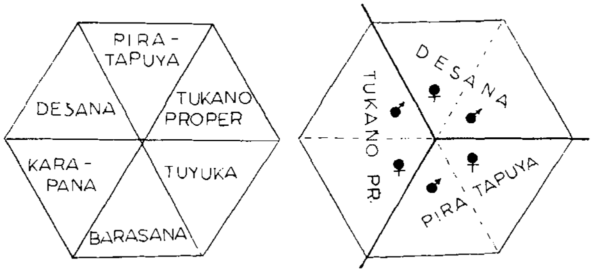

FIGURE 2. The hexagon as territorial unit and social model. Left: The Vaupés territory and the ideal distribution of the six original Tukanoan tribes. Right: The ideal distribution of a phratry of three intermarrying tribes.

three exogamous tribes. Since each tribe consists of males and their virilocal by residing spouses, a phratry can be said to consist of six units. This phratric, tribal, and sexual division is imagined as a series of interrelated, adjoining hexagons. The great celestial hexagon that is projected upon the land is divided into six hexagons representing phratries; each phratry is divided into six triangles, that is, three so-called "male" and three "female" ones (FIGURE 2). Although, at present, this territorial division does not correspond to a social and geographical reality, it continues to be an important shamanistic model, the true origin of which is seen in the sky, and the dynamics of which constitute a body of complex esoteric lore.

A basic principle of Tukanoan social organization is exogamy. Incest laws are very strict and their origins are elaborated in many myths and shamanistic texts. As is often the case in these tribal societies, there is some overlapping of different situations, such as father/daughter incest, mother/son incest, sibling incest, or plain adultery. The human actors in these dramatic situations are personified in the sky, where Sun is either Moon's husband, father, or brother, while Venus is a daughter of Sun or a son of Moon. The precise identification may vary from tribe to tribe, but the essential interpretation is the same: The incestuous (or adulterous) male is castrated and his penis is thrown up into the sky where it turns into Orion's belt. Sometimes the castrated man is a father figure, at other times he is the son who is being punished by the father; in any case, the victim acquires the proportions of a hero.[8]

In Desana shamanist imagery, Orion is the Master of Animals, a supernatural gamekeeper. He is a mighty hunter who can be seen walking over the sky, over the Milky Way, which is his trail, carrying a game

animal, a string of fish, or a basket of fruits, thus announcing the different harvesting seasons.

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In what I have said so far, I haved referred to a number of symbolic equivalences, and before I can continue I must clarify some of these concepts. In Tukanoan ideology, a symbolic or metaphorical relationship is never limited to an one-to-one comparison; symbolic images are always seen as chains of analogies. For example, the Milky Way can be conceptualized as a river, as a trail in the forest, as an immense cortège of people, a cast-off snake skin, a fertilizing stream of semen, and so on. In the same way, the celestial hexagon can be seen as a rock crystal, a tortoise shell, a honeycomb, a womb, a brain, a ritual enclosure, a tribal territory, a fish trap, and so forth. The entire concept of transformation is thus based upon likeness, not identity. Astronomical interpretations are thus always based on multiple chains of analogies, never on one single image.

To continue—I have spoken here of the astronomical models of tribal territories and social organization and I have touched upon the problem of marriage rules. I now must add some observations on native concepts of fertility and growth in relation to astronomy.

According to the Indians, the energy of the universe is generated by the sun. The sun, too, is imagined as a rock crystal that is said to contain an unlimited amount of what the Indians call "color energies." The principal color energies have a male fertilizing power. The moon, on the other hand, contains a female principle of color energies related to plant growth and the human menstrual cycle. Now, solstices and equinoxes are of relatively little importance on the equatorial line, so the sun's cycle is not measured through them, but is taken to be a continuous, perennial force. However, lunar phases and positions in relation to earth and sun are closely observed and are thought to be correlated with female fertility and, in general, with the growth cycles of animals and plants. Most interestingly, the different lunar phases constitute a calendar for birth control, for game protection, and for the restriction of the production of many materials. In fact, every month, during the sixteen or so days between the first and third quarters, sexual intercourse is prohibited, as are hunting, fishing, and the gathering of raw materials for such things as basketry, wood carving, and pottery making. Shamans recommend instead agricultural labor and gathering activities, mainly of insects and larvae. Of course, these prohibitions are not too severe but, since they

are reinforced by shamanist threats of impending illness, they do constitute an effective mechanism of control. The lunar calendar, then, is essentially a guide to the protection of natural resources and a means of population control.

In order to explain the reasons why the first and third quarters of the moon's phases occupy this important position, I must refer to another cyclic phenomenon. The Milky Way is imagined as two huge snakes; the starry, luminous part is a rainbow boa, a male principle, and the dark part an anaconda, a female principle. The cycle of fertilizing forces emanating from the sky is punctuated by the shifting of the Milky Way, which is seen as a swinging motion made by the snakes. Now, in ordinary nature, anacondas and boas are said to copulate at two periods of the year, approximately at the vernal and autumnal equinoxes. Late in March and again in September anacondas swim upriver at night and, now and then, lift about one-third of their bodies out of the water and then slap down with a loud splashing sound. This is part of their mating behavior, but the Indians say that, when the snakes rise out of the water, they watch the stars in order to ascertain the proper time. At these times of the year, and during the nightly shifting of the Milky Way, the Indians transfer the image of the two snakes to that of the intersecting of the ecliptic and the celestial equator, and to the intersections of the path of the moon and the path of the earth, at the first and third quarters. In everyday nature the two equinoctial dates are associated with periods of fertility; by the end of March and the end of September the spawning seasons of fish are beginning and these fish runs provide the model for sib distribution along the rivers, for patterns of reciprocal food exchanges, and for ritual dances in which spawning behavior is equated with human procreation. This, too, is the harvesting season for many wild fruits, and it is the proper time for male initiation rituals.

The image of the intertwining snakes, that is, of two bent, snake-like bodies that intersect at two points––is an important shamanistic icon.[9] It is thought that two snakes lie in the fissure between the two hemispheres of the human brain, and that their rhythmically shifting motion determines the relationship between the unconscious and the conscious in what concerns sex, food, and aggression. Now, this image of the human brain is patterned after the shamanist image of the entire celestial vault as one gigantic brain divided by the great fissure of the Milky Way. The Desana believe that both brains, the cosmic and the human, pulsate in synchrony with the rhythm of the human heartbeat, linking Man inextricably to the Cosmos.

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I must return once more to the hexagonal pattern. The great hexagon in the sky is also an architectural model, and traditional longhouses are built according to this celestial plan. The houses are large structures contained within six points of reference marked by strong houseposts that are identified with stars (FIGURE 3). The middle section of the roof is supported by another set of six strong vertical posts that delimit a hexagonal

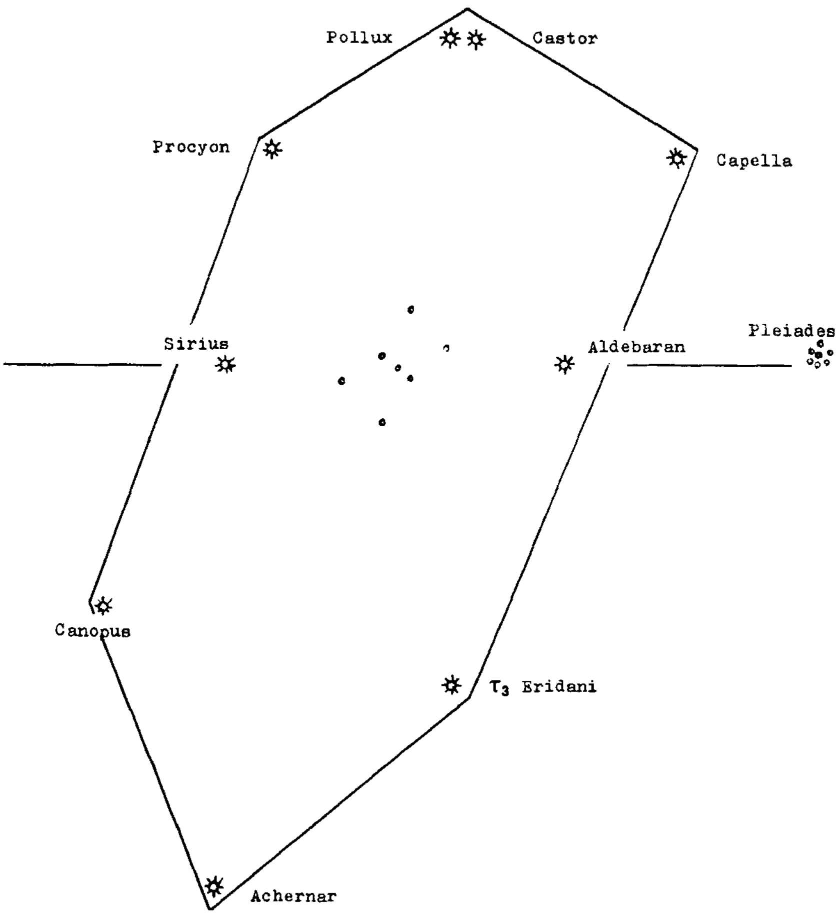

FIGURE 3. The longhouse as an astronomical model; Achernar marks the men's door and Gemini mark the women's door.

central part that has ritual functions.[10] An imaginary line drawn at a right angle to the longitudinal axis of the house divides both the outer and the inner hexagon into two halves and represents the equatorial line. At the same time, it represents the Orion's belt, Zeta and Delta being the middle houseposts, while Epsilon is not visibly marked but coincides with the true center of the hexagon and the house. But this is not all: The basic outline of the structure delimited by the inner hexagon can be perceived, in a very schematic way, as a longitudinal ridgepole and three parallel cross-beams.[11] The Desana see in this the constellation of Orion and, in one shamanistic image, it is a rack upon which the hero is crucified. In this outline, Betelgeuse and Bellatrix are the summer solstice points, Saiph and Rigel are the winter solstice points, and the belt is called the "Path of the Sun". It is at the center, on Epsilon Orionis, where, on ritual occasions—at the two equinoctial dates—heaps of palm fruits are deposited. In this case, the clusters of fruits are identified with the Pleiades, which rise after sunset in the east late in September and set before sunrise late in March, in both cases announcing the onset of the principal fruiting seasons, the fish runs, and the proper time for initiation rituals.

Within the inner hexagon of a longhouse the Indians perform ritual dances related to the multiple symbolism of Orion. Men and women dance in the center, between the six main posts. They dance back and forth, each group representing a "triangle" and this interpenetration of male and female triangles will trace the hourglass-shaped outline of Orion (FIGURE 4). The dancers move back and forth over the dividing line, which is Orion's belt. Now, the front part of a longhouse represents an abstract dimension where shamans and chiefs have their seats, while the back part represents ordinary reality, the domain of women, children, servants, and food preparation. The pattern of Orion thus forms an area of articulation between male and female, light and darkness, fertility and restraint.

Obviously, the most important constellation is Orion. Orion is Man: Man the Progenitor, the Hero, the Hunter, the Sinner and, finally, the Victim. But every year he rises anew and, when people see him resurrected in the sky, shamans remind them of everything this constellation stands for. In some images, Orion is a rack upon which the adulterer has been put; in other images, Orion is a tapir hide stretched out to dry between six stakes; or a potstand, or a fish trap. Orion's belt is the severed penis of the incestuous youth, or the castrated father; in another image, the belt is the adze used to extract starch from split palm trunks, a phallic

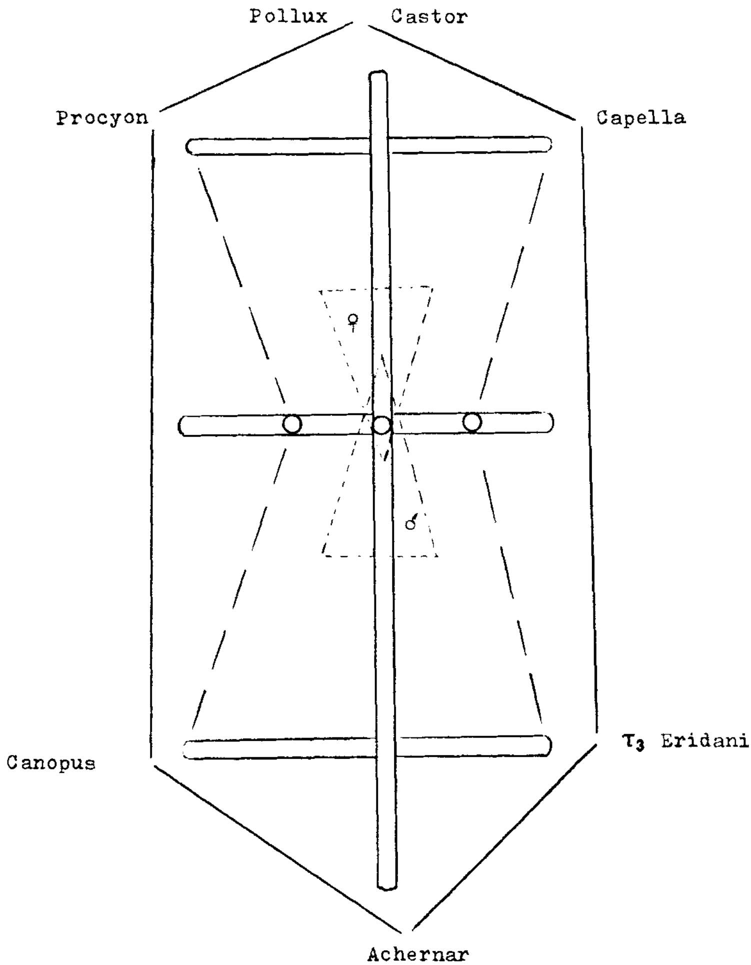

FIGURE 4. The longhouse identified with Orion. The inner hourglass-shaped outline marks the overlapping male/female dance pattern. The diamond centered upon Epsilon Orionis represents a vagina.

instrument that is the main attribute of the Master of Animals. In still another image, the constellation is seen as an evil shaman turned jaguar who had his penis (or tongue) cut off and was hung from a tree and burned; he disappeared in a cloud of smoke and then reappeared in the sky as Orion. Some shamans see in Orion a jaguar copulating with his sister, a huge snake. And, according to the imagery involved, the Great

Orion Nebula becomes a stream of semen, a heap of palm starch, or a cluster of fruits.[12]

What really matters is that this ambivalence of Orion does not offer a simplistic, polarized choice between conventional concepts of Good and Evil, but that it presents the intelligent and searching beholder with a guide to self-knowledge and subsequent adaptive behavior. I shall attempt to reduce a large body of related shamanist concepts to its basic propositions in order to elaborate upon this point.

Among the Desana, all mental and psychological processes are believed to arise in the left cerebral hemisphere, which is said to harbor the unconscious, and where latent ideas must be activated by shamanistic procedures; the induction of altered states of consciousness is essential in this case. Once identified and isolated, an idea must be transformed into an image, an icon. This process of increasing awareness is achieved in the right cerebral hemisphere, while the act of transformation takes place in the great fissure, which, as I mentioned before, contains the two rhythmically twisting snakes. Once the idea has become transformed into an icon, that is, into a culturally coded sign, it can be expressed by action. Now, the three steps of this mental process are represented by Orion: The left cerebral hemisphere is Zeta Orionis, the point of transformation is Epsilon, and the right hemisphere is Delta Orionis.

I have gone into these shamanistic details because I want to make this point: It would be very mistaken to think that the astronomical thinking of these Amazonian Indians refers only to practical affairs of resource management and to the modeling of social organization. Far from it. Shamans are quite explicit about the importance of the philosophical dimensions that capture the mind when contemplating the sky, and will insist that the celestial vault is the one and only model for Man's material and spiritual well-being. Let me give you one more example: The six straight lines of the celestial hexagon that encompass sacred space, both in the sky and on the earth, represent an important metaphysical model, a moral proposition called "the Path, the Way," which the individual must travel in his or her life. In Desana theology the idea of the Quest is very elaborate; it corresponds to a process of individuation, under shamanistic guidance. The starting point for the Quest, for both sexes, is Aldebaran (and, by extension, the Pleiades); this is the place of birth. Thence, men proceed in a counterclockwise direction to Capella, which marks the ritual of naming; from Capella he proceeds to Pollux, where initiation takes place; from there he goes on to Sirius, the star of marriage, and then he turns sharply toward the east and arrives at the center.

This is Epsilon Orionis, the star of procreation, of multiplication, of fatherhood. The last stretch continues toward the east and ends at Aldebaran, now designated as the point of death, of rebirth, and of return. Women travel first in the opposite direction and then, after their marriage at Sirius, they proceed jointly with their husbands. The entire trajectory, a spiritual pilgrimage, divides the human life span into three periods: youth, from Aldebaran to Sirius; maturity, from Sirius to epsilon orionis, and old age, from there back to Aldebaran. In shamanistic imagery these three parts of the life span are marked off by the two intersections of the snakes.

Before turning briefly to other tribal cultures of Colombia, I should like to add one more point. In Northwest Amazonian shamanistic thinking there exists a close relationship between astronomical observations, cosmological speculations, and drug-induced trance states. This gives a very peculiar stamp to native astronomy. Under the influence of a narcotic drug an Indian would imagine himself to be flying through space, ever deeper into unknown dimensions. He would believe himself to be moving among dazzling stars, turning sun wheels, and flashing beams of many-colored lights. At the same time, shamans will point out that the narcotic experience is not as one-directional ecstasy, but an inner voyage that also leads into the many-layered dimensions of the human mind. The human brain, shamans say, is modeled after the celestial vault and the human mind functions according to the stars, which are the ventricles and sensoria of the cosmic brain. Drug-induced trance states develop in a dimension where ordinary concepts of space and time are canceled out; in fact, narcotic drugs are expressly said to constitute a mechanism for modifying space and time and to be a means for exploring other cosmic dimensions where hitherto unknown models for human faculties might be discovered. In using drug experiences, together with the behavioral models encoded in them, as a key to interpret celestial phenomena, shamans can operate with a very convincing mechanism, because all Indians who consume drugs under shamanistic guidance are likely to have similar sensations and experiences.

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I shall briefly refer to the Kogi Indians of the Sierra Nevada. Kogi culture is very different from that of the Amazonian rain forest Indians, and Kogi religion, philosophy, and historical traditions are of a complexity that can be compared only to that of the High Cultures of Mesoamerica. Although, at present, the Kogi form a scattered peasant population,

there still exist lordly and priestly lineages with a strong sense of privilege and rank. The Kogi are agricultualists; hunting and fishing are practically nonexistent.

Kogi astronomical knowledge is based upon the observation of rising and setting points on the horizon and on zenithal observation. A small hole in the conical temple roof admits a ray of sun or moonlight that, in the case of the sun, traces the outline of solstices and equinoxes in the dark interior. Stone alignments, horizon markers, fixed observation points in the form of priestly stone seats, stone circles, gnomons, and similar stone settings, can be found over much of the Sierra Nevada. Kogi villages, ceremonial centers, isolated temples, shrines, and other structures, are always sited according to astronomical principles.

The entire Sierra Nevada is imagined to have a hexagonal plan and to constitute one huge rock crystal, very much like the Desana image of their world. The corners of this crystal correspond to six sacred sites, while, in the sky, they correspond to six first-magnitude stars; the celestial center, again, is Epsilon Orionis.[13] In fact, Orion's belt corresponds to the three principal ceremonial centers, which lie in a line, although many kilometers apart, the middle one of which is designated "the only one".

Since the Sierra Nevada has an approximately conical shape, with rivers radiating in all directions and valleys opening toward the lowlands and the sea, the entire mountain massif constitutes one huge sundial with which the priest-shamans watch the horizons of their particular valleys. All constructions – shrines, roads, and bridges – conform to celestial sightlines; there is not a single spot of any importance in the Sierra Nevada of which the native priests will not say that it has some astronomical implication.

The sky over the Sierra Nevada is, again, conceived as a map of the land with all its topographical details and its mythical geography, being peopled by divine personifications, animals, artifacts, and all kinds of personified forces of nature. In one very telling image, a Kogi priest is described as sitting in the center of a dark temple, holding in his hand a mirror facing upward. A vertical ray of sunlight penetrates the roof and falls upon the mirror surface; but this ray of light proceeds from the disk that is the sun's face, and this disk, too, is a mirror. The reflection is, thus, endless, and expresses the Kogi concept of eternity and the dimension of cosmic space.

The astronomical division of the Sierra Nevada implies a division into clan territories and into a number of lineages that are associated with

particular celestial phenomena. The most important priestly lineage is the one called the "Keepers of the Rock Crystal" and the sacred number six is repeated in many contexts. Once again, Sun, Moon, and Venus represent a triangle that holds the potential for drama. Incest and adultery on earth can be seen in the sky in eclipses, conjunctions, or in the unusually close proximity between two or more celestial bodies. Since all these phenomena are models of behavior on earth that must be followed in detail, ritual incest is practiced on certain occasions.

The scheduling of ceremonies is entirely geared to astronomical happenings; the main ritual dances take place at the solstices and equinoxes, each in a different village. The rituals of the life cycle have their specific shrines and temple mountains, identified with constellations or individual stars. Marriages are celebrated at equinoxes, while death rituals take place on solstices. Temple architecture conforms to cosmological and astronomiocal principles. Although, when seen from the outside, a temple has a circular shape, the interior structure shows a combination of circle, square, and hexagon, which corresponds to sacred spaces that are occupied by particular individuals during ceremonies.

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Let me finally turn to the highland Muiska, the most advanced culture of prehistoric Colombia. In the early sixteenth century the Muiska formed two incipient states; the ceremonial center of one was the Temple of the Sun, while the center of the other was the Temple of the Moon. Both temples were associated with the principal priestly and lordly lineages. The heart-land of the Muiska was formed by a chain of old Pleistocene lake beds that provided fertile soil.[14] It so happens that this chain of flat valley bottoms extends for more than 200 kilometers in a southwest-northeast direction; that is, in the direction of summer solstice sunrise. In other words, by chance of nature, the entire Muiska territory is oriented in this manner, the chiefdom of the Moon Temple being located in the southwestern section, the chiefdom of the Sun Temple occupying the northeast.

Two highland valleys in this territory are known to present a clear, dark, cloudless sky during most of the year.[15] In both valleys one still can observe huge stone columns, alignments, and other stone settings. As observed from one of these structures, the sun rises on summer solstice exactly over a sacred lagoon whence, according to tradition, the Creator Goddess (Bachué) of the Muiska emerged in mythological times.[16] From the same observer's position an alignment of large cylindrical columns runs in an east-west direction.

A constellation of six sacred lakes[17] is located in the central area and is combined with many mountaintops that constitute astronomical sightlines. In the same region, a pattern of Catholic shrines and pilgrimages continues ancient aboriginal models described by the early chroniclers.

Rock crystals have been found in many shamans' graves, and emeralds, also of hexagonal structure, were important as offerings and in other ritual contexts. The overall similarity of these symbolic interpretations is best illustrated by a Muiska myth recorded at the time of the Spanish conquest. The myth tells that the daughter of a local chieftain was impregnated by the rays of the divine sun at a certain date. She eventually gave birth to a huge emerald. The stone burst open and from it emerged a child who grew up to become a great chief.[18]

Among the equatorial Tukanoans there is little interest in a horizon calendar. Zenithal observation is limited to the mythic motif of locating the "center," and all other practical astronomical knowledge refers to cyclic seasonal phenomena, the interpretation of constellations, the nature and motions of the Milky Way, and some aspects of astral proxemics. The great model is the hexagonal rock crystal. All these aspects of calendrics and astronomy exist among the Kogi who, in addition, have the following elaborations: a very detailed horizon calendar, zenithal observations, temples as astronomical observatories, associations between astronomy and weaving, record keeping with notched sticks, and pilgrimages and dances according to astronomical patterns. In both cultures, the sky is a map. Among the Kogi there is less emphasis on the relationship between astronomy and hallucinogenic drugs, and more weight is given to precise observation, to sight lines, record keeping, and the details of ritual structures. Many of these features seem to have been present among the ancient Muiska Indians, among whom we find astronomically-oriented architecture, a division into sun- and moon-associated states, a pattern of pilgrimages, the Sun/Moon incest theme, the hexagonal symbolism of mineral structures, and other details.

All three cultures have, thus, a truly fundamental astronomical substructure. This substructure consists not only of a body of practical knowledge used in timekeeping, but contains complex intellectual elaborations concerning time/space relationships, the importance of biological cycles, and many philosophical formulations. In trying to explain forms of cultural behavior through native astronomy, it is obvious that we must go beyond the utilitarian level of calendars, architecture,

astrology, and so forth, and take into account the intellectual and spiritual aspects as conceived by the Indians, which can be found in, e.g., their concepts of cosmogony and the time/space continuum, and their notion of a participatory universe.

NOTES AND REFERENCES

1. I would suggest that certain ring-shaped shell mounds or midden sites of early prehistoric cultures might have been used as horizon calendars.
2. In the shamanistic world view, the universe is layered. The Desana refer to a sublunary dimension, followed by the spheres of Sun, Moon, and Venus; then comes the Milky Way and beyond that, another, deeper dimension.
3. On the Desana, see the following works by G. REICHEL-DOLMATOFF: *Amazonian Cosmos: The Sexual and Religious Symbolism of the Tukano Indians* (Chicago: University of Chicago Press, 1971); *The Shaman and the Jaguar: A Study of Narcotic Drugs among the Indians of Colombia* (Philadelphia: Temple University Press, 1976); *Beyond the Milky Way: Hallucinatory Imagery of the Tukano Indians* (Los Angeles: UCLA Latin American Center Publications; 1978); "Desana Animal Categories, Food Restrictions, and the Concept of Color Energies," *Journal of Latin American Lore*, vol. 4 (1978), pp. 243-91; "Desana Shamans' Rock Crystals and the Hexagonal Universe," *Journal of Latin American Lore*, vol. 5 (1979), p. 117-28.
4. On the Kogi, see the following works by G. REICHEL-DOLMATOFF: *Los Kogi: Una Tribu Indígena de la Sierra Nevada de Santa Marta, Colombia* (Bogotá: 1950-51); "Notas Sobre el Simbolismo Religioso de los Indios de la Sierra Nevada de Santa Marta," *Razón y Fábula*, no. 1 (Bogotá: Revista de la Universidad de los Andes, 1967), pp. 55-72; "Templos Kogi: Introducción al Simbolismo y la Astronomía del Espacio Sagrado," *Revista Colombiana de Antropología*, vol., 19 (1975), pp. 199-246; "The Loom of Life: A Kogi Principle of Integration," *Journal of Latin American Lore*, vol. 4 (1978), pp, 5-27.
5. On the Muiska, see, among others, JOSÉ PÉREZ DE BARRADAS, *Los Muiscas antes de la Conquista*, 2 vols. (Madrid: Consejo Superior de Investigaciones, 1950-51).
6. See G. REICHEL-DOLMATOFF,[3] "Desana Animal Categories," pp. 265-71, and "Desana Shamans' Rock Crystals."
7. The spot is said to be the rock of Nyí on the Pira-paraná river. See G. REICHEL-DOLMATOFF,[3] *The Shaman and the Jaguar*, pp. 155-56, and *Beyond the Milky Way*, pp. 138-41.
8. On this particular motif, see R. LEHMANN-NITSCHE, "Las Constelaciones del Orión y de las Híadas," *Revista del Museo de la Plata*, vol. 26 (1921), pp. 17-69.
9. Mesoamericanists might recognize in it the Ollin motif.
10. In reality, the six posts form a rectangle, but the space enclosed by them is said to be "like a hexagon." There are some indications that, in former times, houses had a circular ground plan that included six main posts forming a hexagon.
11. The three crossbeams are designated "jaguars." See G. REICHEL-DOLMATOFF,[3] *Amazonian Cosmos*, pp. 104-10.
12. Obviously, Orion symbolism is closely related to the *yuruparí* initiation ritual, but that is beyond the scope of this paper. On the *yuruparí*, see STEPHEN HUGH-JONES, *The Palm and the Pleiades: Initiation and Cosmology in Northwest Amazonia* (London: Cambridge University Press, 1979).

13. On the earth, the center is located at the highest snow peak. This world axis is imagined as a spindle; see G. Reichel-Dolmatoff,[4] "The Loom of Life."
14. Most of these lakes dried up some 30,000 years ago, but the ancient lake bed and the surrounding land provided the best agricultural soils for the Muiska.
15. These are the valleys of Villa de Leyva and of Ramiriquí, both in the Boyacá district.
16. This observation was made at Saquenzipa, near Villa de Leyva. According to myth, the goddess Bachué rose from the Laguna de Iguaque.
17. These lakes are still in existence.
18. Reference is made to the myth of Goranchacha, the Son of the Sun, as recorded by the Spanish chronicler Fray Pedro Simón in *Noticias Historiales de las Conquistas de Tierro Firme en las Indias Occidentales*, 5 vols. (1623; rpt. Bogota: 1882–92).

The Pleiades and Scorpius in Barasana Cosmology

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IN 1905, THE GERMAN ethnographer Koch-Grünberg published a report of an Indian astronomical system from the Northwest Amazon region.[1] His account, based on drawings by two Indian informants, has remained one of the most comprehensive descriptions of ethnoastronomy from lowland South America. Scattered references to star lore in the works of other writers,[2] together with Koch-Grünberg's own word lists of the many different languages spoken in the area,[3] suggest that the basic elements of the system he described are probably common to all the Tukanoan-speaking Indians of the Vaupés and to their Arawakan-speaking neighbors to the north. In his account, Koch-Grünberg identifies some seventeen named stars and constellations and states that knowledge of astronomy is used in time reckoning, orientation, and the regulation of agricultural activities. But little information is given, either by him or by other writers, as to how this knowledge is used and how it relates to the cosmology and world view of the Indians involved. In this paper, I shall try to answer some of these questions with reference to the Barasana.

The Barasana are a Tukanoan-speaking group of forest Indians who live on the Río Pirá-Paraná in the Colombian Vaupés region.[4] Their subsistence is based on slash-and-burn agriculture, fishing, hunting, and gathering. Like many tribal peoples, they believe that they live at the center of the world. In their case, living as they do directly on the equator, this belief receives some objective support from the fact that twice a year they see the sun directly overhead at midday and, at night, the stars appear to revolve around the earth in straight paths going from east to west through the zenith. The vertical sun, the marked east-west

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orientation of celestial phenomena and the fact that, in this area, the rivers tend to flow from west to east, all play important roles in the ritual and cosmology of these Indians.

The universe is believed to be composed of three basic layers—the sky, the earth, and the underworld—and each layer is likened to the round pottery plates on which manioc bread is baked. The sky and underworld are modeled on earthly experience, so each is described as having forests and rivers and as inhabited by people. The large communal houses or malokas of the Barasana, each containing some twenty to thirty individuals, are representations of their cosmos. The roof is the sky held up by the house posts, which are mountains, and the points of light where the sun shines through holes in the smoke-blackened thatch are the stars. The floor is the earth, with limits defined by the walls, a ring of mountains like the upturned edges of the cassava griddle, and underneath is the underworld and underworld river. Like the cosmos, the house is conceptually (though not always actually) oriented along an east-west axis. The front door used by the men is in the east and the women's door at the back is the west. From west to east down the middle of the house runs an invisible river, the counterpart of the Pirá-Paraná that bisects the world. In the frame of the roof, a long horizontal beam called the "sun's path" (*muhihu ya ma*) runs from east to west. The center of the house, reserved for men and for public ritual, is the center of the world, and above it in the roof is a vertical post called the "seat of the sun" (*muhihu ya bota*), a name that also refers to midday.

According to myth, the first beings, or Universe People (*umuari masa*), the sun, the sky, the moon, and the stars, were created by the Primal Sun (*Yeba Haku*) as his children. The creation of the human beings that followed them is presented as a process involving the death of these first beings and their subsequent return to immortal life in a world of space and time that is opposed to that of mortal men. On earth, the rivers run from west to east whilst those above and below run from east to west; when it is day on earth it is night in the sky and underworld; and the dead in one domain are the living in another so that, in myth, dead stars buried in the sky fall to earth to marry living mortals and dead people buried in the house fall to the underworld, where they become living spirits. By their very presence, the sun and stars unite the past with the present and their movements in space and time unite a series of opposed principles upon which the fertility and continuity of the universe depend. They unite the living with the dead, the east with the west, men with women, earth with water, the wet season with the dry, and above and

below with the earth in the middle. Significantly, marriage itself, upon which both sexual and social reproduction depend, is also seen as a union between different spatial domains. The Barasana are an exogamic group classified as Earth People. They intermarry with the Tatuyo who are Sky People and the Bará who are Water People.

The daily and yearly movements of the sun and stars are linked together both in direct experience and in metaphor. The sun (*muhihu*) and his children the stars (*nyokoa*) revolve around the earth each day, traveling from east to west in the sky and then from west to east up the underworld river below. The alternation between night and day is metaphorically linked with that between the wet season and the dry so that the dull sun of the wet season is sometimes presented as a different being from its bright counterpart and brother and may be identified with the moon. The stars, in their nightly passages, also repeat their annual movement from east to west and each year they are said to return to the east as flocks of migratory birds whose passage corresponds to the heliacal setting of particular constellations. The Pleiades return as bobolinks (*Dolichonyx oryzivorous*), Orion's belt and sword as unidentified small black seed-eating birds, and other constellations as egrets (*Leucophoyx thula*).

Although all stars are said to be people, only some are selected to be given names and individual identities. Of these, most lie along the Milky Way or Star Path (*nyokoa ma*), which is close to, but distinct from, the path of the sun (*muhihu ya ma*). Though the overall path of the stars is from east to west, the diagonal orientation of the Milky Way with respect to the ecliptic serves to divide the Star Path into two segments, a New Path (*mama ma*) running from southeast to northwest and an Old Path (*bukʉ ma*) running from northeast to southwest. The Old Path is said to have come into being before the New but today it is the New Path that precedes the Old in the annual cycle.

When asked about them, the Barasana frequently list stars and constellations in sequential order. These lists, which usually begin with the Pleiades, which mark the beginning of the year, relate the succession of stars to that of the seasons, which are either named directly after stars or after tree fruits that have their celestial counterparts. Before discussing some of the ordering principles of their astronomy, I shall follow the Barasana example and outline their zodiac in the form of a list (FIGURES 1 and 2).

At the beginning of the New Path is (1) the Star Thing (*nyokoaro*) or Pleiades. After which follows (2) the Small Umarí Fruit Fence (*wamʉ*

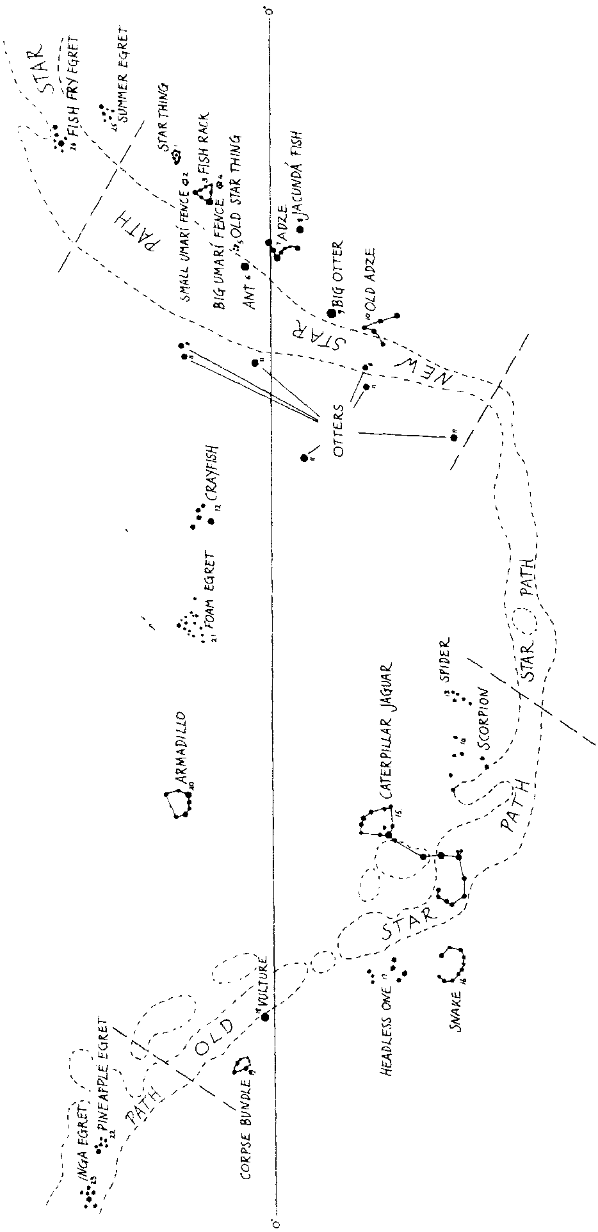

FIGURE 1. The Barasana Zodiac.

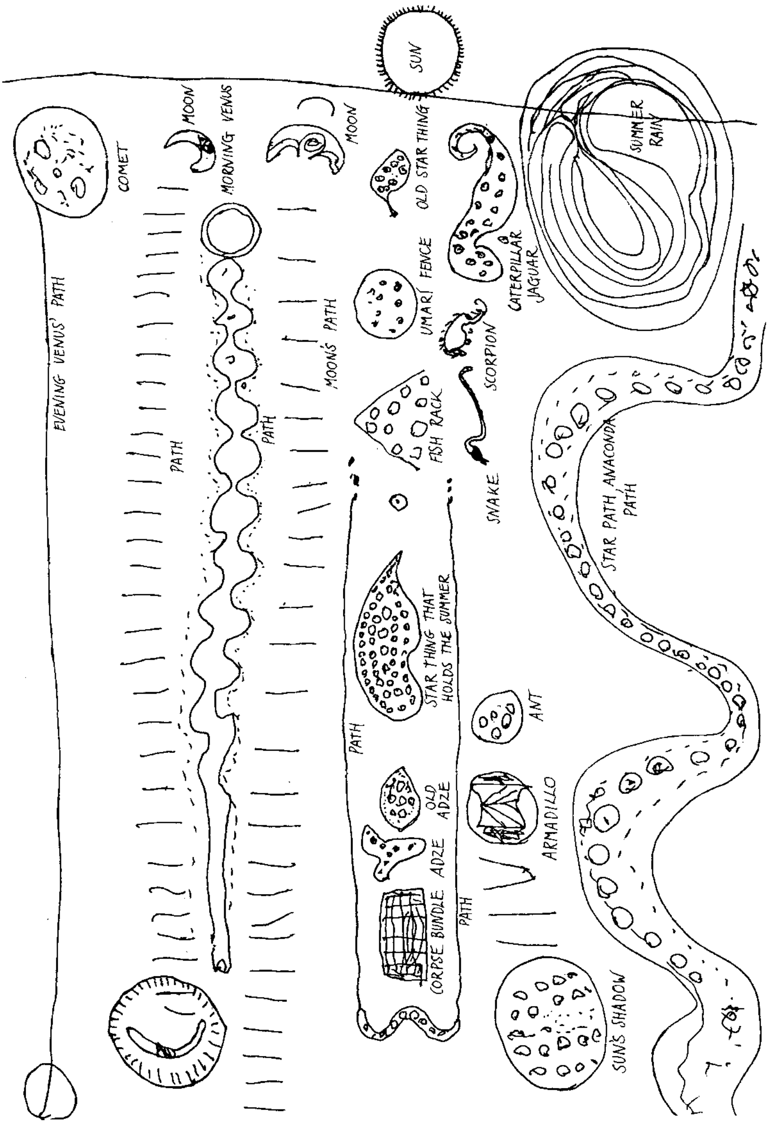

FIGURE 2. The heavenly bodies as drawn by a Barasana shaman.

saniro kīhika), a circular cluster of stars to one side of the Hyades, probably in the region of υ, κ, and ω of Taurus; then (3) the Fish Smoking Rack (*wai kasabo*), the triangle of the Hyades; then (4) the Large Umarí Fruit Fence (*wamu saniro haigu*), a cluster on the other side of the Hyades near π of Taurus and also circular in shape; then (5) the Old Star Thing (*nyokoaro bukurã*), a group of stars paired with the Star Thing and probably Orion's head (λ, ϕ_1, and ϕ_2 of Orion); then (6) the Leaf-Cutter Ant (*mekahiamu*), Betelgeuse (α of Orion), whose reddish color is likened to that of the ant; then (7) the Adze (*sioruhu*), the belt and sword of Orion. This elbow-shaped constellation represents the stone-bladed adzes that were once used as agricultural implements and then as ritual ornaments worn over the left shoulder when dancing but that have now disappeared completely;[5] then (8) the Jacundá Fish (*Chrenichicla sp.—muha buhua*), Rigel (β of Orion); then (9) the Big Otter (*Pteronura brasiliensis—timi haigu, maha hesau*), Sirius (α of Canis Major); then (10) the Old Adze (*sioruhu bukurã*) probably δ, ε, and η of Canis Major and paired with 7 above; then (11) the Small Otters (*Lutra sp.*)—(*wania timia, ria timia*), each a single bright star and including Procyon, Castor, Pollux and various others beyond Sirius; finally, (12) the Crayfish (*rasikamu*) is included in this group and probably forms part of Leo.

Leading the Old Path is (13) the Poisonous Spider (*buhu*), probably a group of stars in the upper portion of Centaurus; then (14) the Scorpion (*kotibaha*), probably parts of either Centaurus or Lupus; then (15) the Caterpillar Jaguar (*īya yai*), Scorpius but sometimes with parts of Lupus and Libra added as feet; then (16) the Poisonous Snake (*anya*), which is usually identified with Corona Australis but sometimes other snakes, all *Bothrops* species, are given as stars or star-groups nearby; then (17) the Headless One (*rihoa mangu*). This is the headless corpse of an eagle called *Wekomi*, the mythical father-in-law of both Morning Venus (*busuri nyoko*) and Evening Venus (*nyamikarima*), whose head was cut off in error by his own daughter Star Snake (*nyoko anya*), one of the snakes mentioned above; then (18) the Vulture (*yuka*), Altair (α Aguila), a star that announced the season for raiding and killing when warfare was still practiced; then (19) the Corpse Bundle (*masa hoti*), Delphinus, which is the body of a Star Woman killed by a swarm of wasps sometimes identified with the Pleiades. She fell to earth, came back to life and married a mortal who went with her to the sky, only to be killed by another star in the form of a snake. An unidentified line of stars nearby is the vine ladder up which they traveled. Finally, (20) the Armadillo (*hamo*), Corona Borealis, is included in this group, though its place in the sequence varies according to different informants.[6]

Besides these two main groups, various other stars and constellations are recognized and named, most of them being either egrets or forest fruits. They have in common the fact that they lie between the two Star Paths and the fact that they are all connected with rain and water. It is as if they served to reintroduce an element of continuity into a yearly cycle broken into two halves by the division of the Milky Way. I shall return to this point below.

Taken together, most of the names of stars and constellations reported by Koch-Grünberg from elsewhere in the Vaupés region correspond closely to those of the Barasana though, in some cases, the stars to which they apply differ. These names reveal certain patterns: they refer to a relatively small number of classes, mostly birds, fruits, insects, fish and other aquatic creatures, and some objects of human manufacture. Notably absent are any stars named after the game animals that are hunted for food. I suggest that this has to do with the fact that game animals are firmly classed as belonging to the earth – in myth they are presented as the kinsmen of a hero called *Yeba* whose name means Earth – and, as such, they are opposed to creatures of the above and below, the sky on the one hand and the water and underworld on the other. It is probably also related to the fact that, of agriculture, hunting, fishing, and gathering, hunting is the productive activity least affected by seasonal changes.

Each Star Path has a focal constellation, with the others being described as its "companions" and it is these which receive the greatest degree of symbolic elaboration. The Star Thing or Pleiades, the leader of the New Path, is the most important constellation in the Barasana zodiac. As Woman Shaman (*Romi Kumu*), who is the sky, the creatress, and the first shaman, the Pleiades figure prominently in myth and ritual symbolism and their movements regulate the seasonal, agricultural, and ritual calenders. The Star Thing is a woman, the Star Woman whose eight stars are eight strips of wood like those used to set fire to the dry wood of a cleared swidden site or chagra. Each strip is marked with alternating bands of red and black: the red is the fire of a burning chagra that lights up the eastern sky and brings the dry season and the black is the charcoal that remains after the fire is out and is the dark, overcast sky of the rainy season. Star Woman, the Pleiades, thus controls the seasons and agriculture. In November she appears at dusk on the eastern horizon and heralds the end of the rains and the start of the swidden cycle, the clearing of the forest by men; overhead in January and February, she marks the dry season when the chagras are burned; and in April, as she sets in the west at dusk, she marks the end of the dry season and the onset

of heavy rains that will fertilize the manioc planted in the chagras by the women.[7] Star Woman's fire stick is also the summer sun, which is extinguished by the rains and the Pleiades as a whole are seen as a nocturnal counterpart of the sun.

The two fruiting seasons of the ingá tree (*Ingá dulcis L.*) coincide with the evening rise and set of the Pleiades and the sweet, white pith of its fruit is likened to the brilliant white of this constellation. Similarily, the fruiting season of umarí (*Poraqueiba sericea*), another cultivated fruit, coincides with the two constellations that bear its name. In addition to fruit, the constellations of the New Path are all associated with either food itself—ants, fish, and crayfish—or with its production—chagras, adzes, and fish racks—and its consumption—otters. As companions of the Pleiades, these stars are collectively linked with the dry season from December to March and they are described as being "good," an evaluation that is consistent with their association with a time of year when food is abundant and when much visiting and feasting takes place. This is also the time of the summer sun.

If the connotations of the New Path are positive, those of the Old Path are equally negative. The first four constellations, Spider, Scorpion, Snake, and Caterpillar Jaguar, are all poisonous creatures. (Many of the caterpillars of Amazonia cause skin irritations and some can cause serious illness.) In addition to being poisonous, such creatures are also believed to be the vehicles of attacks by sorcery. The next four, the Headless One, Corpse Bundle, Vulture, and Armadillo, are all linked with death, graves, and putrefaction and the myths about them all concern tales of sorcery. It should be added here that, at lunar eclipses, the moon is said to come down to earth in the form of an armadillo that digs up graves and devours the bones of the dead—near the Armadillo constellation are three stars in a line that are called the "Armadillo's Bone." The Old Path is described as old, worn-out, and decayed and its stars as "bad." Again, this is consistent with the fact that they dominate the sky during the rainy season from April to November when food is scarce, social life is reduced, and people are prone to illness. This is the time of the winter sun, which is obscured by clouds and rain.

The focal constellation of this group, the Caterpillar Jaguar or Scorpius, is a very ambivalent creature, variously described as a jaguar with a snake for a tail or as a snake with jaguar only for a name. As a jaguar, it is linked with Forest Fruit Jaguar (*he rika yai*), the master of forest fruits, and a cluster of stars in the region of ζ of Scorpius, called the "jaguar's testicles," are also identified with tree fruit. As a snake, the con-

stellation is identified with the category *hino*, which embraces both large nonpoisonous constrictors (*Boidae*) and also mythical ancestor figures of whom a snake is only one manifestation. The eggs of this snake are the cluster by ζ of Scorpius and its tongue is the blade of the ritual adze, itself a constellation (see above).[8] This constellation is one manifestation of Jurupari Anaconda (*he hino*), whose earthly representative is the rainbow boa (*Epicrates cenchris*). A snake constellation identified with Scorpius is found throughout the Vaupés region and, in many parts of Amazonia, Scorpius is identified with Boiassu, the Great Serpent.[9] The Caterpillar Jaguar is the "father of snakes" (*anya hakʉ*) and is responsible for their creation. As it and its companion the Snake pass their zenith and begin to set in October, snakes become especially visible and aggressive and this is presumably the time when many of them breed.

A number of writers have reported a jaguar constellation for the Vaupés region and Koch-Grünberg identifies this jaguar with Cetus.[10] This constellation, and especially its whiskers (α Cetus and other stars), is associated with suden violent rains. The Barasana associate the Caterpillar Jaguar with rain and thunderstorms as it begins to set at dusk, a period that would roughly correspond with the evening rise of the head of Cetus. It is thus as if, in the Caterpillar Jaguar, the Barasana have merged the values and associations of two different constellations, common to the whole Vaupés region, into one.

The period from June to August, when the Caterpillar Jaguar rises higher and higher in the sky at dusk, is the time when many species of butterfly and moth breed. As these caterpillars begin to pupate, they come down from the trees on which they feed and become a significant item in the Barasana diet at a time of year when other food is scarce. The Caterpillar Jaguar is also the "father of caterpillars" and is responsible for their increase. His children, the Caterpillar People (*ĩya masa*) have colored hairs and brightly patterned bodies that are likened to the feather ornaments and body paint that men wear at dances. The rapid growth and metamorphosis of caterpillars is an apt metaphor of regeneration and continuity through change, and their dances are said to keep the seasons moving. But, in addition to providing food, these caterpillars are dangerous creatures who send sickness and death to human beings. Theirs is the season of storms, thunder, and lightning, which are vehicles of sorcery. As one informant put it, "they want us to make friends and join them in their dances so they call us. If we respond, our soul (*ʉsʉ*) is taken away, we join them and we die. If we dream of a jaguar at this time it is the Caterpillar Jaguar who comes down to eat our souls." Cater-

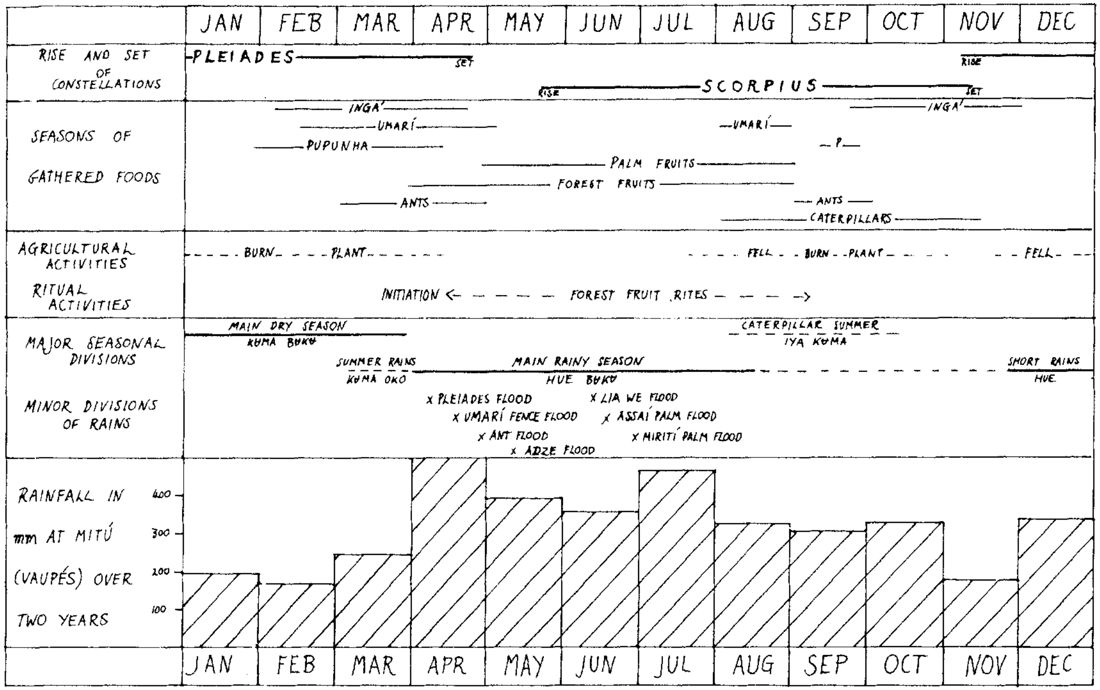

FIGURE 3. Barasana seasonal calendar. Rainfall data taken from *Atlas de Colombia* (Bogotá: Instituto Geografico "Agustín Codazzi," 1969), p. 67.

pillars belong to the world above and have only a temporary existence on earth. They come from the world of the dead and are dressed in the costumes of spirits, the ornaments that humans wear to enter the spirit world at dances.

The contrast between the Star Thing (the Pleiades) and the Caterpillar Jaguar (Scorpius) and between their respective companion stars can now be related to the Barasana seasonal calendar (FIGURE 3). The year is divided into periods of *hue*: heavy rain, high water, and overcast skies and periods of *kʉma*: little rain, low water, and sunny weather. *Kʉma* also means "year" and, at one extreme, the contrast between *kʉma* and *hue* is that between the main dry season from December to March and the rest of the year, which is relatively wet. In gross terms, this contrast is equivalent to that between the Pleiades and Scorpius, for they are visible during opposed seasons; when one is at zenith, the other is at its nadir. At the other extreme, these terms are used to refer to any (even quite short) period of sunshine or of heavy rains.

The yearly cycle begins with the evening rise of the Pleiades, which announces the dry season and the season of cultivated fruits. Star Thing is associated with ingá fruit (see above), and a heroine of myth called Ingá Woman (*Meneridyo*) is identified with Old Star Thing, a constellation paired with the Pleiades.[11] As the Pleiades signal ingá fruit, so the umarí fruit constellations "remind" people to fence their trees to keep the falling fruit from wild animals. The ending of the dry season is marked by short bursts of heavy rain called summer rain (*kʉma oko*) and is a time of exceptional growth and fertility. The rain triggers the breeding flights of edible leaf-cutter ants (*Atta sp.*) and coincides with the time that the Ant star (Betelgeuse) passes its zenith. The rain and rising waters also precipitate the spawning of many species of fish and edible frogs (*Leptodactylus* and *Osteocephalus sps.*), which are easily caught at this time. The true end of the dry season in April is a time of very heavy rain and flooded rivers. The first big rains are called the Star Thing rains (*nyokoaro hue*), after the Pleiades, which are then setting in the west at dusk. Thereafter follow a series of rains, named after the constellations Umarí Fruit Fence, Ant, and Adze, which come one after the other at this time.

With the heavy rains, the rivers flood and shoals of aracú fish (*Leporinus sp.*) come upriver to spawn. The Fish Rack (Hyades), called "the man's rack" (*masʉ ya kasabo*) at this time, "reminds" people to set traps and prepare for the abundance of fish. As the rains continue and the rack, now called "the otters' rack" (*timia ya kasabo*), sinks lower in

the sky, the fish cease to spawn and become scarce in the flooded rivers. This scarcity is accredited to the otters who come down from the sky to eat up the fish. The main rainy season is the time when wild tree fruits, mostly palm species, come into season and are gathered in large quantities in connection with ritual dances. The most important palm fruits, mirití (*Mauritia flexuosa*), assaí (*Euterpe oleracea*) and *cõha* (*Mauritia gracilis*?), lend their names to subdivisions of the rainy season and each has a star or constellation to which it corresponds. Unfortunately, I am not yet able to give precise identifications for these stars, though all of them appear to lie in an area around Corvus.

As the head of the Caterpillar Jaguar climbs higher into the sky, the rains gradually slacken and, around the time that it reaches its zenith in August, there is a short and variable dry spell called the caterpillar summer (*ĩya kʉma*), when caterpillars grow big. This fine period is like a miniature version of the main dry season (*kʉma bʉkʉ*). The rivers begin to fall, the cultured fruits ingá, umarí, and pupunha (*Guilielma gasipaes*), whose main crops are in February and March, come briefly into season and people make chagras to plant crops of maize. As in the case of the long dry season, the rains that end this dry spell trigger the breeding flights of ants and the spawning of frogs and fish. But, despite sharing some of the positive attributes of the dry season, the caterpillar summer remains an ambivalent time of year, for the weather is unpredictable, storms are frequent, and food is both scarce and inherently dangerous. As the Caterpillar Jaguar and Poisonous Snake sink low in the sky in October, the rains become heavy and persistent and the rivers rise, a period called the caterpillar flood (*ĩya hue*) and snake flood (*anya hue*). With the reappearance of the Pleiades at dusk in November marking the start of the new cycle, the rains begin to slacken and the dry season begins.

At dusk, men, women, and children often sit in family groups on the cleared sandy space in front of the maloka; this is the time when most observations of stars are made. Attention is focused upon the vertical position of different stars with respect to the eastern and western horizons. Seen from this perspective, the movements of the Pleiades and Scorpius show a distinct pattern, for they are visible at opposite times of the year and, in each case, their rising brings the end of rain, their zenith marks a dry season and their descent to the western horizon coincides with the onset of rains. That the ascent of stars appears to stop rain

whilst their descent appears to bring it on can be related to ideas concerning the Milky Way. The Milky Way is variously described as being a reflection of the Milk River on earth or as a continuation of that river in the sky. The Milk River (*ōhekoa riaga*) on earth is a huge river in the east, often identified with the Amazon and Río Negro. The sky is described as a dome and compared to the hemispherical gourds with black-glazed interiors used to contain coca powder. On the horizon, the dome of the sky meets the earth so that the Milk River in the sky is continuous with that on earth. The east, or Water Door (*oko sohe*) is also said to be like a waterfall sending water to the world below whilst the water that falls over the sides of the flat-topped mountains brings water from the world above. As earthly rivers flow west to east whilst those in the sky and underworld flow east to west, the totality makes a closed system that continuously circulates water through the three cosmic domains (FIGURE 4). Water flows downstream to the east, where it is taken up into the sky by the Milky Way and brought down again on the other side in the west. As the constellations rise, they take up water from the earth to cause a dry season and, as they come down again, they bring celestial water as rain. Like day, the dry season is conceptually located in

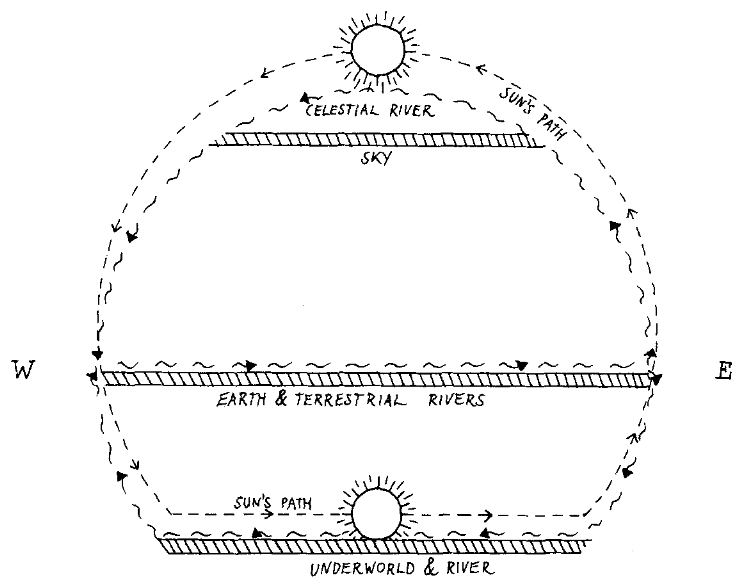

FIGURE 4. Circulation of water through the Barasana cosmos.

the east, which is the male domain in domestic space; like night, the wet season comes from the west, the domain of women. The Milky Way and water are thus mediators between cosmic domains and uniters of opposites. Water is also a source of fertility that causes plants to grow, trees to bear fruit, and animals to breed.

It was suggested above that the egret constellations appeared to mediate between the two halves of the Milky Way and, thus, to maintain its continuity. One of these, (21) the Foam Egret (*somo yehe*—Coma Berenices), lies halfway between the two star paths (FIGURE 1). The others, (22) Pineapple Egret (*sena yehe*—parts of Lacerta), (23) Fish Fry Egret (*imika yehe*—α Perseus and surrounding stars), (24) Summer Egret (*kʉma yehe*—β Perseus and surrounding stars), and (25) the Ingá Fruit Egret (*mene yehe*—part of Cassiopeia), all lie in a line along the Milky Way between the Old Path and the New. These constellations and birds are strongly linked with water. The egret is called the "master of water" (*oko ʉhʉ*) and is said to bring cold, mists, and rain, and the small groups of migrating egrets that arrive every week or two throughout the rainy season are likened to the succession of rains. More generally, their pure white, mist-like breeding plumes (*uga*), greatly valued for the making of dance ornaments, are associated with the Milky Way. They were created by Woman Shaman, who is herself identified with the sky and, in particular, with the Pleiades. In revenge for her theft of the sacred Juruparí flutes, her brother had caused her to menstruate and now threatened to kill her. To stop him, she made egret plumes from her long flowing hair and offered them to him.[12] These plumes are the Milky Way, which is also called the "hank of hair" (*nyokoa hoa hani*). This myth fragment suggests that there is some connection between hair and menstruation, a connection that is made quite explicitly in other contexts when it is said that it is their hair that causes women to menstruate.

The implied connection between menstruation and the Milky Way emerges more forcefully in the association made between the menstrual and seasonal cycles. The rainy season is the menstrual period of the sky personified by the Woman Shaman. In the dry season, the world becomes old and tired and is then refreshed and rejuvenated by the rains. The key to this process lies in the Pleiades, which is identified with a gourd of wax (*werea koa*) owned by Woman Shaman. The gourd is her vagina and the wax her menstrual blood, which melts. Woman Shaman offered men immortality in the form of her gourd but they refused to eat from it. She put the gourd under her body and there snakes, spiders, and scorpions, Scorpius and its companions, came and ate from it and are

thus able to shed their skins. Menstruation as an internal change of skin is equated with ecdysis, an external skin change. The march of the seasons is seen as an endless cycle of skin changes, first by Star Woman, the Pleiades, and then by Caterpillar Jaguar, Scorpius. For immortal stars, the life cycle is merely a matter of a skin change but, for human beings, it is literally a matter of life and death.[13]

The myth I have cited here stresses skin changing and immortality, but another version stresses poison and death. In this one, snakes, spiders, and scorpions eat from a pot of curare poison to become poisonous themselves and Woman Shaman appears as a sexually voracious ogress whose pubic hair is made from fish poison vines. The Pleiades and Scorpius are thus opposed, but each also combines within itself the values of its opposite in reversed proportions. The life-giving Pleiades, visible in the dry season when food is abundant, also has a sinister side and brings rain as it sets. Death-dealing Scorpius, visible in the rainy season when food is scarce, heralds a short dry season and a relief from hunger as it rises. In sum, Scorpius appears as a wet season counterpart of the Pleiades and a number of other myths, too many to recount here, could be cited to support this assertion.

It was stated above that the Pleiades are considered to be a nocturnal counterpart of the sun. Evidence for this assertion comes from the identification of the Pleiades with Woman Shaman (*Romi Kumu*) and specifically with a gourd of wax identified as her vagina. This gourd of wax is also stated to be the sun and, in myth, Woman Shaman is the owner of fire, which she keeps in her vagina. Like Woman Shaman, the sun also has a cyclical existence, becoming old and tired in the rainy season and appearing young and renewed when the dry season returns. The present sun, a male creative principle, is a child of the Primal Sun (*Yeba haku*) and, like the Pleiades, a female creative principle, it has a double aspect. The Primal Sun had two male children, one older than the other, who had a quarrel about who should be brighter, older, and more dominant than the other. One threatened to use his heat to burn up the world and to cause women to become sterile by drying up their wombs. The other, taking his brother's heat and light away, promised to ensure fertility through a regular alternation between wet and dry. In terms of the yearly cycle, these two are the sun of the dry season and the sun of the rainy season, which, in our terms, are the sun of the winter solstice and the sun of the summer solstice. In terms of the daily cycle, they are the sun and the moon, who are both called *muhihu* and distinguished as *umuagu*, "of the day" and *nyamiagu* "of the night."

We are thus presented with a series of opposed principles, wet and dry, male and female, east and west, day and night, above and below, wild and cultivated, life and death, which apply to a series of temporal processes, the seasonal cycle, the life cycle, the flow of the rivers, the use of domestic space, agricultural activities, etc. But it is important to note, firstly, that, although gender plays an important part in these contrasts, they should not be confused with or reduced to sex and secondly, that, whilst metaphoric links are made between these pairs, these links are contextual and processional and not fixed and static. Thus, whilst in some contexts the west end of the house is female and the east end is male, in others this spatial contrast may relate to those between hosts and guests, kin and affines, or men and spirits. Similarly, whilst male agricultural activities dominate the dry season and female ones the wet, the Pleiades are more female than male and Scorpius more male than female. The significance of the heavenly bodies lies in the fact that, through their movements in space and time, they unite together all these opposed principles and this accounts for their dual nature. Things that go round and round and up and down in a cosmos in which opposed fixed points have opposed values are bound to have this synthetic quality and it is precisely this that makes them objects of power and veneration for the Barasana.

▲ ▲

So far, I have been talking largely on a theoretical level. I would like to conclude on a more practical note by indicating how elements of the system outlined above are put into action in the context of ritual dances. For the Barasana, astronomical knowledge is not simply a cognitive system, but also one that gives men power over the natural world. The shamans who hold this knowledge assert that it allows them to control growth and fertility for social ends and that, through the proper ritual procedures, it is they who keep the cosmos moving. In these ritual dances, the ornaments of the dancers, the movements they perform, and the timing of the ritual calendar all draw on the system I have described for their symbolic efficacy.

The feather ornaments worn at dances enable men to enter the world of spirits and, therefore, they are closely associated with that world. On the one hand, they are used as grave goods and the underworld river is said to be awash with them. On the other hand, they are made largely of bird feathers and birds, as we have seen, are closely identified with the stars who live in the immortal world of the sky. The main components of

the dancers' headdress reflect the opposed principles mentioned above. On the front of the head, a crown-like band of yellow and red macaw feathers is worn—this band represents the sun. Behind, stuck into the banana leaf stalks that have now replaced the long bound hair worn in the past, a mass of white egret plumes is worn with two egret wings hanging over the back. These plumes and hair are the stars and the rain and the totality of ornaments on the head represents a cosmic synthesis.

The dancers dance in a line with a lead dancer (*baya*) in the middle surrounded by his companions on each side, an arrangement reminiscent of the focal constellation and its companions in each star path. The dancing takes place in a house that represents the cosmos; the line of dancers dances round a path that surrounds a central area identified with the center of the world. The dancing always begins on the central axis of the house at the front or east end. From there, the line of dancers moves round the dance path to the left or right but always towards the rear of the house and the west. In their movements round the house, the dancers thus replicate the east-west rotation of the sun and stars, which are represented by their ornaments, the vertical plane of the cosmos being transposed to the floor of the house on which they dance. These dances begin on one day and must go throughout the night to the next, with the most important ritual events taking place at dusk, midnight, and dawn.

The annual round of the stars and seasons is also replicated in the annual round of dances that make up the ritual calendar. During the rainy season, as the forest fruits ripen, each kind is ceremonially brought into the house by the men who play sacred Juruparí flutes (*he*). The fruit is given to the women and comes as a gift from the forest spirits whose voices are the instruments that the women are forbidden to see. These rites (*he rika sõria wi*) are the occasion for shamanic practices designed to ensure the continuity of the seasons, the fertility of the trees, and the ripening of the fruit. In this context, the ornaments worn by the dancers represent forest fruit, each item representing a different species, and the bodies of the dancers represent the trees. Once again, we see the link between the ornaments and stars for, as explained earlier, tree fruits also have their celestial counterparts. At the beginning of the dry season, cultivated ingá fruit, whose ripening coincides with the appearance of the Pleiades, is brought to the house in a rite similar to that for wild fruits, but one that forms the first stage of male initiation. The growth and maturity of the fruits symbolize the desired growth of the initiates who are brought in with them. The rest of the dry season, when food is abundant, is the time for dances at which smoked fish and meat are

ceremonially exchanged between affinally related maloka communities.

The climax of the ritual calendar occurs at the end of the dry season (March-April), when the main initiation rite (*he wi*) is held. The timing of this rite is determined by the position of the Pleiades, which should be low on the western horizon at dusk. The rite is thus timed to coincide with the conjunction of the opposed principles discussed above (dry season-wet season, Pleiades-Scorpius, male agricultural activities-female agricultural activities, cultivated fruits-wild fruits). It also coincides with the vernal equinox, when the sun is in balance between its wet and dry season extremes and in a vertical position at both midnight and midday and thus "sitting" squarely on its seat in the center of the house (see above). The myth of the origin of this rite can be interpreted as making reference both to the equinox and to the conjunction of the zenith and nadir positions of the sun. The story concerns two solar beings who travel together up the underworld river. At midday (midnight on earth), they stop, test each other's powers, and conclude that they are of equal strength.[14]

This ritual is the most important of the whole ritual cycle and it is, above all, in this context that human space and time take on cosmic proportions. During the rite, the participants chant together continually, asserting that they are at one with their ancestors and doing what their ancestors have always done. They take hallucinogenic drugs that alter their perceptions of space and time and give direct access to the world portrayed in myth. The house, built as a replica of the cosmos, becomes the universe itself and the cycle of night and day takes on the proportions of the year. At the same time, the layers of the cosmos are conjoined and the living are united with the dead. Sacred instruments representing the bones of the ancestors are taken from their hiding places at the bottoms of rivers and brought up to the house. There they are assembled and given life and voice by the men who play them. In mythic terms, these instruments come from the underworld and are brought to life on earth.

The climax of the rite occurs at midnight, when two men representing the sun and dressed in full costume play sacred flutes up and down the east-west axis of the house. At the same time, the initiates eat coca powder from a sacred gourd of beeswax (*werea koa*). This gourd of wax represents the Pleiades, the sky, and Woman Shaman as a female principle (see above). The flutes represent Jurupari Anaconda (*He Hino*) and Scorpius as a male principle. Given the timing of the rite and the ritualized conjunction of sacred objects that represent opposed but complementary principles, it should now be easy to understand why the

Barasana believe that if this rite were not held regularly, the universe would come to an end.

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4. Research amongst the Barasana was carried out between September 1968 and December 1970 and between July and December 1979. The research was funded by the Social Science Research Council of London, England. This support is gratefully acknowledged.
5. In a previous work S. Hugh-Jones, *The Palm and the Pleiades. Ritual and Cosmology in Northwest Amazonia* (Cambridge: Cambridge University Press, 1979, p. 145), I incorrectly identified the adze constellation as being composed of Orion's belt together with Bellatrix (α Orionis) and Betelgeuse (γ Orionis).
6. Stars and constellations were identified with the aid of a number of different informants and using a flashlight as a pointer. Identifications were matched against star maps in the field and subsequently checked against D.H. Menzel, *A Field Guide to the Stars and Planets* (Boston: Houghton Mifflin, 1964).
7. The dates of rise and set of stars and constellations are taken from tables supplied by Dr. Anthony F. Aveni (see A.F. Aveni, "Astronomical Tables Intended for Use in Astroarchaeological Studies," *American Antiquity*, vol. 37 (1972) 531-40) but, in order to avoid distorting ethnographic reality, I have not stated them in numerical terms.
8. Patrice Bidou, personal communication.
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10. T. Koch-Grünberg,[1] p. 61.
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12. Patrice Bidou, personal communication.
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Catachillay

The Role of the Pleiades and of the Southern Cross and α and β Centauri in the Calendar of the Incas

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INTRODUCTION

OUR KNOWLEDGE of the Inca calendar is based on information gathered by the Spanish chroniclers who wrote about Cuzco, the capital of the Inca empire in southern Peru, after it had been conquered in 1532. They left us data not only about the importance of the sun and the moon in calendrical reckoning, but also about the importance of two groups of stars. The Pleiades and the Southern Cross and α and β Centauri played complementary roles in the calendar. In Andean society, both groups were worshiped by herders of llamas. When the former are visible during the whole night in November, the latter would already have passed their lower culminations at midnight in October, and when the Pleiades are invisible from about the middle of April to the beginning of June, the other stars would have their upper culminations at midnight. The use of complementarity of constellations for calendrical determinations is also seen in other cultures. For instance, the Acehnese of Northern Sumatra use the constellations of Orion and Scorpio to calculate sidereal months of 27 or 28 days.[1] Recently, Urton analyzed ethnographical data from a modern village near Cuzco, Misminay, establishing an opposition between the Pleiades and the Tail of Scorpio.[2] In the case of the Incas, the observation of the Pleiades and of the Southern Cross and α and β Centauri decided the position of their sidereal lunar calendar within the year.

After a short description of the character of the calendar I will discuss

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the data on these two groups of stars, their calendrical importance, and the word *catachillay*, or *catachilla*, as it is used in connection with both.

THE CHARACTER OF THE INCA CALENDAR

The Inca Calendar combined a solilunar count with a sidereal lunar count. The first used a sequence of twelve synodic lunar months, starting with the month that included the day of the June solstice, 21 June. In order to establish this correlation, the Incas made two observations of the sun. The first was of sunrise on 25 May. The first new moon after this date belonged to the month including the June solstice. This observation was made from Coricancha, the central temple of the sun in Cuzco. The second observation, confirming the first, was of the first full moon after 4 August, which belonged to the month of planting. Then a series of observations were made during the ensuing thirty days by means of a group of four pillars erected on the gentle slope of Picchu, a mountain 2 km west of the central plaza of Cuzco, from which they were observed. The setting sun, moving at this time of the year from north to south, passed the northern pillar on 4 August, between the two central pillars on 18 August, and the southern pillar on 2 September. These thirty days defined the fixed period of a synodic month, but actual months could begin up to fifteen days earlier or later. The "fixed synodic month" represented their average value (FIGURE 1).

The Incas had a specific astronomical interest in the two dates 18 and 4 August. On the former date, the sun goes through nadir and the full moon closest to that date passes at midnight through, or near, zenith. The second date, 4 August, is close to midseason, 5 August, between the June solstice and the September equinox. When there is a full moon on the June solstice there is also a full moon on 18 August; the two observations support each other calendrically.[3]

The sidereal lunar count was important in the spatial and political organization of the city of Cuzco and its surrounding valley. Our data derive from a system of 41 directions, called *ceques* ("lines"), which were established from Coricancha, the temple of the sun.[4] Their purpose was two-fold; two functions that have to be distinguished sharply. *Ceques* as sightlines toward the horizon enabled the Incas to give a topographical description of the valley, including data on mountains, rivers, springs, irrigation canals, roads and social divisions, and to make astronomical observations on the horizon. The position of sunrise on 25 May was

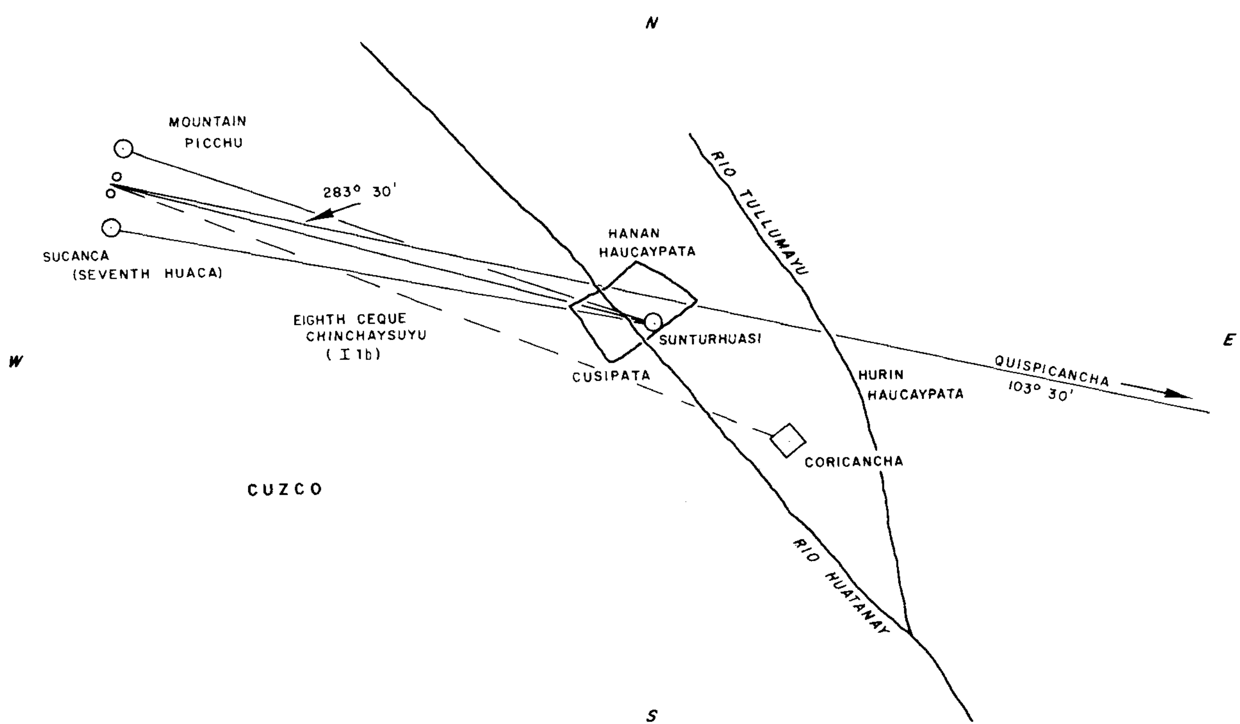

FIGURE 1. When the sun goes through nadir, on 18 August, it sets in between the inner pillars; sunsets occurring in between the outer pillars during the period from 4 August to 2 September are used to define the month of planting.

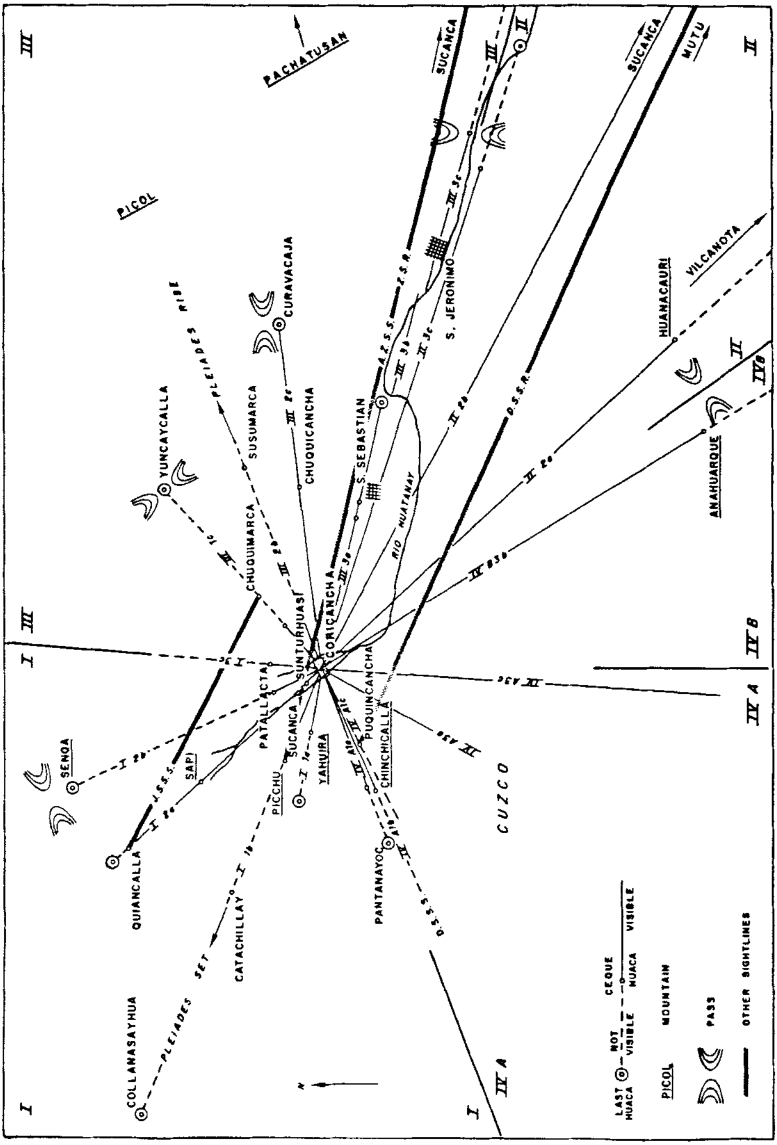

FIGURE 2. A map of the valley of Cuzco with *ceques* as used here and in Zuidema.[5]

defined by a *ceque*. So was the position of sunset on 18 August, but here the observation was made from a particular point on the plaza and not from Coricancha. In this case, as in other similar cases, we need to know both the horizon point and the observatory since the latter cannot always be assumed to be Coricancha (FIGURE 2).

The other purpose of the *ceque* system was to obtain a calendar in the strict sense of the term, that is, a count of the days in the year that is repeatable over the years. Calendrical reasons explain the way that the directions of the *ceques* were established – not only by 41 horizon points, but also by various markers in the terrain on or close to each of these directions. The markers could be natural features, like rocks or springs, or man-made ones, like houses or a road leaving the valley. As such, they were worshiped and called *huaca*, "sacred." People worshiped a *huaca*, or a *ceque*, or a group of *ceques* according to a hierarchy of social divisions distinguishing size, rank, and location. Each *huaca* was worshiped on its own day, thereby creating longer periods of worship for *ceques* and groups of *ceques*. In this way, the *ceque* system became a calendrical instrument.[5]

The numerical information contained in the *ceque* system was recorded on a *quipu*, a group of knotted strings, where a *ceque* probably was represented by a string and each *huaca* of the *ceque* by a knot. Using the *quipu* like a rosary, Inca *quipu* specialists informed the Spaniards about the list of *huacas* in Cuzco, their locations, and the purpose of their worship. Although each Inca town had a *ceque* system, only for Cuzco do we have the complete sequence of *huacas*. On the basis of this list, we are able to reconstruct the internal structure of the calendar.

Cuzco was divided into four quarters or *suyus*, I, II, III, and IV, with nine ranked *ceques* in each (FIGURE 3). The hierarchy of *ceques* descended in groups of three; this is indicated by the numbers 1, 2, and 3 and the letters a, b, and c. The *ceques* in IV are an exception: 14 *ceques* are divided into two groups, IV_A and IV_B, of seven (3 + 3 + 1) *ceques* each. In one case, the *ceque* consists of two directions (IV_A 3 a, c), but the *huacas* are counted in sequence, making one *ceque*. In FIGURE 4, I have correlated the *ceque* system with the calendar to which my research in this and in other articles has led. Each *huaca* has the space of one degree on a circle that represents one year. The numbers and letters of *ceques* do not represent directions, but dates in terms of the Christian calendar; dates that I will explain later. In the case of *suyus* II and IV, the day precedes the date given; in the case of *suyus* I and III, it follows it.[6]

Even a glance at the numbers of *huacas* and *ceques* will suggest a

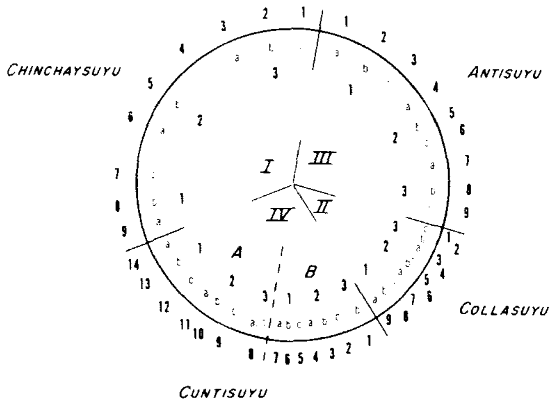

FIGURE 3. A schematic representation of the *ceques*. Outside circle: names of *suyus* and numbers of *ceques* as given by Cobo.[4] Inside circle: the hierarchical organization of *ceques* as given in Zuidema, *Ceque System*.[4]

calendrical purpose. There are 328 *huacas* representing a period equal to twelve sidereal lunar months ($12 \times 27\frac{1}{3} = 328$). Given that, in the Andes, a week has eight days, this period contains 41 weeks ($41 \times 8 = 328$), a number equal to that of the *ceques*. Our account of the *ceque* system specifies the connection of each group of three *ceques*, each of which represents a period from 23 to 33 days, to one of the twelve major political divisions of Cuzco. There is moreover, mention that connections did exist between each division and a specific month-long period in the year. But our sources do not tell us how to read the *ceque* system as a calendrical *quipu*. Various questions arise. Does the fact that there are 328 *huacas*, and not 365 or 366, mean that 37 days were not counted by the *ceques*? Are these 37 days taken as one period or not? Where did the count of the *huacas* start and in what direction did it proceed?[7]

Two reasons of a rather general nature induced me to suggest a reading in a clockwise direction, going from II around to III, beginning in early June and ending at the beginning of May. First, early data from different parts of Peru place the beginning of the year at the reappearance of the Pleiades in June.[8] Second, with this reading we obtain a correspondence between the hierarchical *ceque* system, following first an ascending order of *ceques* and then a descending one, and the pattern of increase and decrease that can be observed in terms of the sun – first the days become longer and warmer, then shorter and colder – of the Pleiades – they are visible every night first for a longer, then for a shorter time – and of the agricultural cycle – plants grow when rains increase

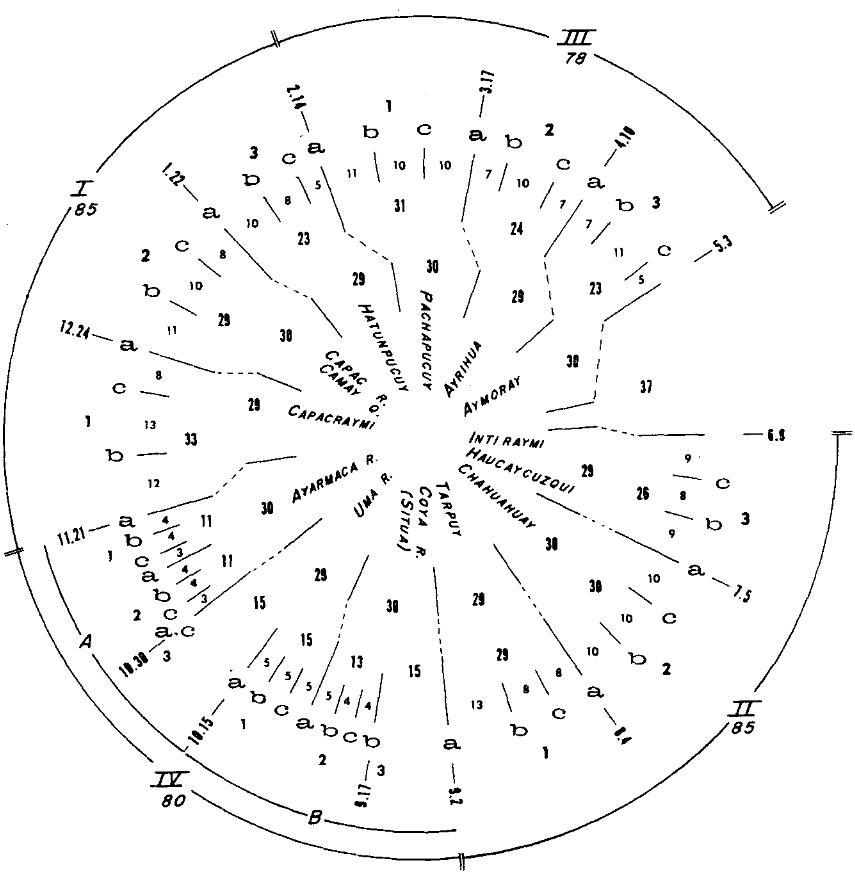

FIGURE 4. The calendar, numerically interpreted using the *ceque* system as a *quipu*.

and ripen when rains decrease. The sidereal lunar cycle was tied to the cycle of the Pleiades: their first heliacal rise in June, their first heliacal set after 21 November when the counting of *huacas* began in I, and their last heliacal set in the middle of April. The 37 extra days, that is, the time from the beginning of the harvest to the preparations for the new agricultural year were not counted. These days were, however, given ritual attention by other means.[9]

In this way, we can, using the *ceque* system as a calendar, account for the dates that the Incas were most interested in. We can explain the irregularity of the number and distribution of *ceques* and of the number of *huacas* in *suyu* IV. *Ceques* in *suyu* IV are used, in their two functions,

both as sightlines and as part of the calendar, for the observation of the Southern Cross and α and β Centauri. *Ceque* IV_B 3 b, the first *ceque* of the first half of *suyu* IV counting clockwise, is directed to the part of the horizon where these stars rise, while *ceque* IV_A 3 a, c, the first *ceque* of the second half, with its two directions, frames the part of the horizon where they set. Although the Southern Cross and α and β Centauri are not circumpolar at the latitude of Cuzco, they are close enough to the south celestial pole to be visible at some time of the night during the whole year. When they have their lower culminations at midnight in September and October, they are visible first when they set just after sunset and then when they rise just before sunrise. They are, thus, "quasi-circumpolar." Unlike stars further removed from the south celestial pole, their first heliacal set occurs before their last heliacal rise. The calendrical *ceque* system in *suyu* IV includes the time from the first heliacal set of the Southern Cross to the last heliacal rise of α and β Centauri and then the entire time that the Pleiades are visible during the whole night.[10]

The astronomical significance of the *ceque* system in *suyu* IV was first suggested to me by data, included in a chapter on stars, in the mythical history of Huarochiri; this data was written down at the end of the sixteenth century.[11] Huarochiri is a province in Central Peru and is also one the sources of the data on the first heliacal rise of the Pleiades and its importance for the beginning of the year. No such explicit calendrical information is available from Cuzco. But we do have data from Cuzco on the rising and setting points of the Pleiades and of the Southern Cross and α and β Centauri. In this article I will argue that these two groups of stars have the same astronomical importance in Cuzco as elsewhere in Peru and that they support the interpretation of the *ceque* system as a calendar given above. Both groups of stars are still important in Andean indigenous astronomy. They are known under various names. However, one name that occurs in the chronicles is used for the Pleiades as well as for α and β Centauri—*catachillay*, or *catachilla*. On the basis of the data from Huarochiri, we will be able to analyze their complementary roles in Inca astronomy and calendrics.

Concluding this introductory description of the sidereal lunar calendar, I will return for a moment to the comparison with the sidereal lunar calendar of the Acehnese of Sumatra. They used two complementary constellations to define twelve sidereal months in relation to twelve synodic months. By subtracting two or three days from every next synodic month, the dates of the corresponding sidereal month were obtained. The sidereal months are movable, as are the synodic months. In

the Inca case, the sidereal lunar calendar had a fixed position in the year. It was used to measure various of their calendrical and astronomical interests: the fixed period from 4 August to 2 September was correlated with the length of a synodic month, and the passages of the sun through zenith and nadir and heliacal rises and sets of stars, primarily those of the Pleiades and of the Southern Cross and α and β Centauri, were determined. Although the Incas were probably aware of the regular recurrence of the sidereal month, they only recorded data concerning their major astronomical interests.

THE PLEIADES

The Pleiades were, and are, known in Quechua—the language of the Incas, which is still spoken in southern Peru—by various names; for instance, *collca*, ("storehouse"), *onqoy* ("illness"), and *qoto* ("pile").[12] Bertonio, our source for Aymara as spoken around Lake Titicaca, calls them, besides *hucchu*, *mucchu*, and *vicchu*, *catachilla huarahuara* ("star catachilla").[13] One of our most trustworthy early chroniclers of Cuzco, Polo de Ondegardo, uses the same word, *catachillay*, but he applies it to a constellation that he describes as a llama with her young. We can identify this constellation with the stars α and β Centauri, which are still called *llamapa ñahuin* ("eyes of the llama").[14] The *ceque* system mentions a *huaca* Catachillay that I will relate to the direction where the Pleiades set. The direction of Pleiades rise was of great interest in Cuzco and here mythological data refer to the same name. Catachillay, therefore, seems to have been known in Cuzco as a name for the Pleiades. This data allows us to study the two directions of Pleiades set and rise in terms of the Inca calendar.

PLEIADES SET

The name *catachillay* is given to the tenth *huaca* on the eighth *ceque* of Chinchaysuyu (I 2 b). The direction of the *ceque* is 21° north of west and can be defined exactly because of the known location of its *huacas*.[15] *Huaca* Catachillay is beyond Coricancha's horizon. The seventh *huaca* of this *ceque*, called Sucanca and located on the horizon, enables us to identify *catachillay* as a name for the Pleiades.

Sucanca comprised the central pillars of the set of four mentioned above. These pillars indicated not only the period from 4 August to 2 September, when the sun moved from the north to the south, but also the period from 10 April to 10 May, when the sun moved from the south to

the north at the time of harvest. The last heliacal set of the Pleiades was observed around 15 April. The space on the horizon in between the outer pillars was used for observing the Pleiades from Coricancha and for observing sunset from the plaza; these two events were linked because they were observed at about the same time. This fact obliges us to postulate certain Inca practices of observation and calendrics that we can confirm in a discussion of the Pleiades rise. In A.D. 1500 the Pleiades set some 2½° north of the central pillars of Sucanca but still south of the northern pillar. At the time of their last heliacal set, the sun had just passed the southern pillar. If we accept that the name of *huaca* Catachillay refers to the Pleiades, then we must argue that the Incas were not interested in knowing exactly either where or when the Pleiades set, but that they had a precise calendrical interest in sunset during that time. The direction of the *ceque* was not used to identify the Pleiades but rather to couple their last heliacal set – in itself a matter of interest – to an exact time in terms of the sun.

Huaca Catachillay was described as a spring of water. This fact and the data on Pleiades rise will be useful for understanding a reference to the Pleiades as the "swimming ones" that I will mention later.

PLEIADES RISE

Establishing the interest of the Incas in Cuzco in the first heliacal rise of the Pleiades depends upon the interpretation of the alignment of Coricancha, the Temple of the Sun; the beginning of the Inca year; and a spring of water, called Susurpuquio, over Cuzco's horizon in the direction of Pleiades rise, the direction Coricancha is aligned with.

CORICANCHA

The Temple of the Sun consisted primarily of a rectangular enclosure (*cancha*) (FIGURE 5). The eastern wall remains almost complete. The western wall was curved; it was built on a terraced hillside that has recently been almost completely reconstructed. Most important in the *cancha* are four magnificent rooms; the smaller eastern rooms are located against the outer wall and the larger free-standing western rooms face them. The inner face of the outer wall in between the eastern halls has niches, as do all four rooms. The southeast and northeast corners of the northern and southern western rooms, respectively, are connected by a wall with a large gate in the middle. The Spanish chroniclers mention

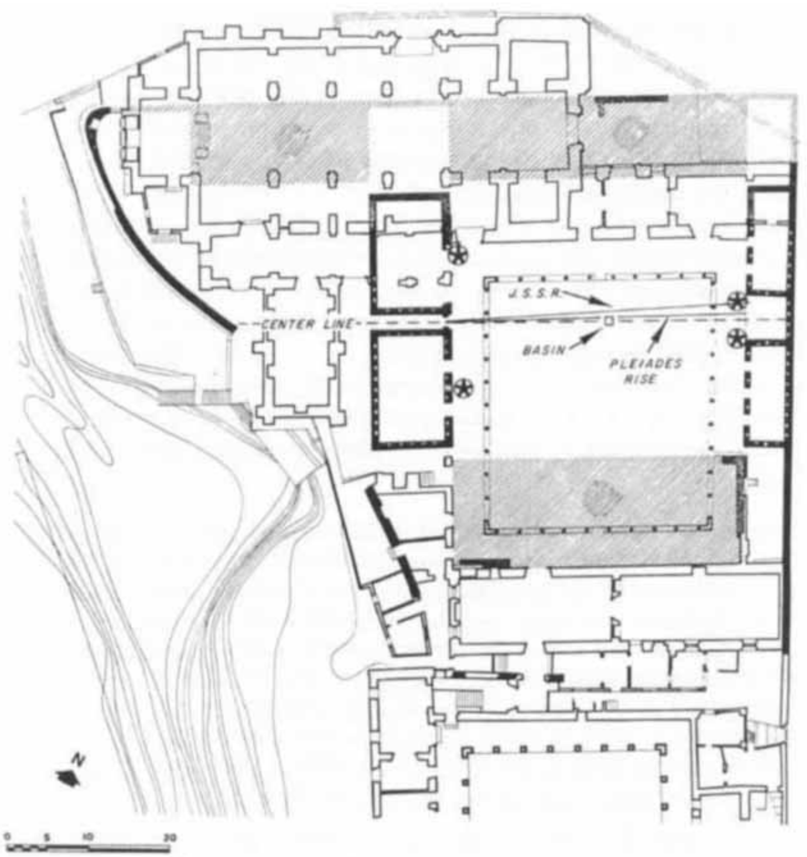

FIGURE 5. A plan of Coricancha showing astronomical alignments, the gate in between the western rooms, the central basin, the four places (indicated by asterisks) with holes for fitting gold and precious stones, and the wall in between the eastern rooms. After Gasparini and Margolies.[16]

that, in the middle of the four rooms, there was a basin used for libations to the sun god. When the Dominicans built the church of Santo Domingo on the northwest side of the courtyard of their monastery, they included the four rooms into the monastery, destroying part of the two northern rooms and moving the basin somewhat further south. Recent excavations by the Cuzco archaeologist Barreda Murillo confirm its original location. In between its two entrance gates, the southwestern room has a large niche with holes bored at various places along its edge, which were said to hold gold and precious stones.[16] The other western room original-

ly had a corresponding niche. On the other side of the temple, similar attention was given to fitting gold in the stone, not in niches, but in the southwestern and northwestern corners of the northern and southern rooms, respectively. (The four places with gold are indicated in FIGURE 5 by asterisks.) Four architectural components suggest that the east-west axis of the temple was used for astronomical observation: (1) the gateway in between the western rooms, (2) the basin, (3) the space in between the eastern rooms, and (4) three holes at floor level near the middle of the wall in between the eastern rooms, which were probably used for drainage from the basin. Some asymmetric features of the building become most prominent and obvious in relation to this axis. In the following description of the astronomical measurements we made (FIGURE 5), I follow Aveni's analysis, taken from his notes of the research that we carried out in Coricancha in 1980, reproduced here with his permission.

> Our transit measurements reveal that the west wall faces azimuth 66°44′ (average of two measurements taken in 1976 and 1980) ± 5′ and that the east wall faces 248°13′ (two 1980 measurements) with the same probable error. Therefore, the walls are antiparallel by 1°29′. The actual eastern horizon is elevated 5°36′ above the true horizon. Sunrise at the June solstice in A.D. 1500 occurred at 64°20′, or about 5 discs of the sun (27 days) to the left (north) of the alignment. The Pleiades rose at 65°58′ (off 46′ to the north) in A.D. 1500; at 66°22′ (22′ to the north of the alignment) in A.D. 1400; and at 66°46′ (2′ to the south) in A.D. 1300, i.e., in the early 14th century this star group was aligned exactly with the wall.

The western wall of the western rooms, as measured from the gateway, faces 66°44′; that is, it is oriented towards the exact center of the eastern wall in between the rooms. There is a 27-day difference between sunrise during the June solstice and the sunrise above the center of the eastern wall. The date of the heliacal rise of the Pleiades is around 6–9 June.

THE BEGINNING DATE OF THE INCA CALENDAR

Our best authority on Inca calendrical rituals, Molina, opens his description with the following statement:[17]

> May. And they started to count the year in the middle of May, plus or minus a day; at the first day of the Moon — this month at the beginning of the year they called *haocay cusqui*, in which they performed the following ceremonies called *intiraymi*, which means feasts of the Sun.

In the present-day calendar, Molina's 1573 "middle of May" is about

26 May—the Gregorian calendar was not introduced in Cuzco until 1584. *Haocay cusqui* or *intiraymi*, two names that Molina and other chroniclers used for the same month, celebrated the June solstice, 21 June. A month including 21 June has to begin after 25 May with a full moon after 7 June. Various chronicles and documents from Central and Northern Peru in the sixteenth century mention the heliacal rise of the Pleiades as the beginning of the year; we can confirm this conclusion from Molina's data for Cuzco.[18]

Coricancha is not only aligned to a sunrise on 25 May, corresponding to Molina's "middle of May, plus or minus a day," but also is close to Pleiades rise, some two weeks later. Molina explains, however, that the interest in 25 May was because of the synodic lunar count. In the fixed synodic lunar count full moon fell on the June solstice—with another full moon on 18 August—and new moon on 7 June, that is, during the first heliacal rise of the Pleiades. The alignment of Coricancha combined an interest in this coincidence with an interest in the earliest possible date of the new moon belonging to the (movable) month of *intiraymi*.

SUSURPUQUIO

Molina, the chronicler who gave us our most precise information about the beginning of the Inca year, also mentions an interesting myth about the sun god rising out of a spring called Susurpuquio ("spring *susur*"). This spring can be identified in the *ceque* system with the eighth *huaca* of the fifth *ceque* of Antisuyu (III 2 b), mentioned as "a spring called Susumarca that is in Callachaca." Callachaca is known also in another version of the same myth, in which the sun god appears in the same direction as Coricancha but on its horizon.[19] Callachaca and Susumarca are still well-known place names and are recorded in documents. Susumarca is a hacienda, built on Inca foundations and terraces, some 5 km northeast of Cuzco along a small stream flowing toward the southeast. The general direction of *ceque* III 2 b conforms to the alignment of Coricancha, some 23° north of east. Susurpuquio, the "spring *susur*" seems to be, then, the spring of the place (*marca*) called *susu*.[20]

A relationship between the Pleiades as *catachillay* and Susurpuquio (Susumarca) is suggested by a poem in Quechua, published in 1631 in a bilingual manual for priests by Juan Perez Bocanegra, a priest in a town near Cuzco who himself was an expert in Quechua. It is of interest, therefore, to compare the myth as found in Molina with the poem.[21]

The myth tells how a prince, later called Pachacuti Inca, defended Cuzco against the attack of another people, the Chancas, when his father

the king had fled from town. On the eve of the battle Pachacuti visited the spring *Susurpuquio* and saw a flat crystal fall into the water. A man came out of the water—he was adorned with serpents and puma skins and his head was crowned with three rays like rays of the sun. He said, "Come here, my son, don't be afraid, for I am the Sun your father and I know that you will conquer many nations." The figure then disappeared; the mirror of crystal stayed in the spring and the Inca took and kept it; and they say that he saw in it all the things that he wanted.

Duviols pointed out that the detailed description of the sun god and his dress was only included in the chronicles after the Spaniards had seen the real golden image of the sun god, of similar appearance, in 1572.[22] As Susurpuquio (Susumarca) is found in the direction of sunrise on 25 May (as seen from Coricancha), the myth seems to refer to the sun of the new year, the sun of the June solstice month that the Incas called Huayna Inti "young sun." The poem of Perez Bocanegra suggests that the crystal thrown into the water refers to his emergence as a birth. The poem is directed to the Virgin Mary, "Bliss of Heaven," "tree of uncountable fruits," "Guardian of God, Mother of God, a white dove, white flower." One verse of special interest to our theme I give here in the transcription and translation of Bruce Mannheim:[23]

Chipchiykachaq qatachillay	Glittering catachillay
P'unchaw pusaq qayantupa	Daylight's guide, dawn's aurora,
Qam waqyaqpaq, mana upa	For you, crier who doesn't listen,
Qesaykikta "hamuy" nillay	To you despised, just say "come."
Ph'iñasqayta qespichillay	Make him forgive my anger,
Susurwana	*Susurwana*

Of immediate interest to us is how the verse combines the words *catachillay*, referring to the Virgin Mary, and *susurwana*, a name for the Virgin Mary in which we recognize the root *susur* of *susurpuquio*. Since colonial times, Andean religion has had a tendency to associate the Sun (*inti*) or the Sun of the Day (*p'unchaw*) with Christ, and the Virgin Mary with Pachamama, the Earthmother. It is not strange to see the Virgin here called *catachillay*, as the "Guide of Daylight and the Sun" and as the "Aurora of Dawn" out of which daylight and the sun are born, given Andean ideas about the Pleiades. Cobo said of the Pleiades that, from them[24]

> came forth the virtue by which they (the other stars) preserve themselves; for this reason they are called the "mother" and all the other *ayllos* and families considered them universally as a very principal huaca: all the peo-

> ple knew them, and those who understood something of this kept track of their course during the whole year more than of the other stars.

These ideas are an elaboration of what Polo de Ondegardo had already said, that the Pleiades were worshiped by all people together while "other stars were worshiped by those people who in particular needed their favor."[25] The Pleiades were a universal mother, like the Earthmother.

The similarity of the Pleiades and the Earthmother is supported by the metaphorical use of "crystal." In the myth, a flat crystal falls in the water before the sun god emerges; later, the "mirror of crystal" stayed in the spring and the Inca took and kept it. "Crystal" is translated from the Quechua *quespi*, a word also meaning "translucent thing," "transparent water." From this word are derived *quespichiy* ("to free, to save from danger"), and *quespi* or *quespilla* ("going safe and free from danger"). *Quespilla*, combined with *casilla* as a synonym, was an important epithet of Pachamama, the Earthmother. From the same root *casi* is derived the name of the month of June in Aymara, Casivi pakhsi, dedicated to the harvest and the reappearance of the Pleiades. In Cuzco, the month of August, in which the next planting was prepared, was called *quispi*, in the hope that the thunder and sun gods would give a calm and prosperous year. Since the poem describes *quespichiy* as an action of the Virgin, who was called *catachillay*, the epithet *quespilla casilla* was probably applied, not only to Pachamama, but also to the Virgin and the Pleiades.[26]

Elsewhere in his book, Perez Bocanegra says that the Pleiades, together with certain lakes, were worshiped because they multiplied llamas. He calls them *uchu capac huaita capac* ("the royal small ones, the royal swimming ones").[27] This data suggests that the Pleiades rose from the spring Susurpuquio and set in the other spring Catachillay, both springs being located beyond the immediate horizon from Coricancha. We will see a similar association between α and β Centauri and llamas and water. A comparison between Molina's myth and Perez Bocanegra's data suggests that the Pleiades as *catachillay* were instrumental in the rising of the sun god from Susurpuquio and that this rising was considered to be a birth from the water and from the Pleiades, the mother of the other stars. They were the mother not only of stars but also of Huayna Inti, the "young sun" of the new year and the June solstice.

We can now come to a more astronomical and calendrical analysis of these mythological data. The *ceque* of Susurpuquio was located in the same direction as the alignment of Coricancha. Coricancha was aligned not only toward sunrise on 25 May, but also toward Pleiades rise. Their

first heliacal rise was important calendrically, as was their last heliacal set in between the pillars on Picchu. The 328 *huacas* of the *ceque* system represented a period in the year comparable to the period that the Pleiades were visible. Their first and last appearances were registered, not by observations of the events themselves – observations that are very difficult to make – but by precise observations of the sun in terms of the solilunar calendar. We can best account for the *ceque* system as a calendar by accepting 9 June as the first heliacal rise of the Pleiades and as the first day of the Incaic sidereal lunar year.

THE SOUTHERN CROSS WITH α AND β CENTAURI

The Southern Cross and α and β Centauri were and are the best known of constellations, the former because of a dark patch of interstellar dust in the Milky Way found within the constellation – a dark patch known in Western astronomy as the Coalsack – and the latter because of another "dark cloud constellation" known as a llama, of which α and β Centauri are the eyes.[28] The Southern Cross, β Centauri, and α Centauri rise, in that order, within a space on the horizon of some 7° around 30° east of south. Their direction of rising from Coricancha is well indicated by a *ceque*, the 14th of Cuntisuyu (IV$_B$ 3 b), called Anahuarque, which is directed to a mountain of the same name. Anahuarque as a mythological character plays a very important role in the cosmology of Cuzco. Elsewhere, I have described in detail various mythical elements; here I will stress only those needed for my argument.[29] The myths and calendrical rituals concerning Anahuarque can be compared to others of Huarochiri in Central Peru, where the importance of the celestial llama for Andean astronomy is mentioned.[30]

Anahuarque was the only mountain in the area of Cuzco to rise with the waters of the Flood, saving the ancestors of the people who lived in the valley before the Incas. In Inca times, their descendants worshiped the mountain as their ancestress. She married an Inca king, she and other women giving him numerous descendants in the original population. Mountain Anahuarque was said to have been very "light" during the Flood; every year, in commemoration of that event, boys to be initiated raced from the mountain to Cuzco, each boy running together with a young llama. At the end of the race each boy was received by a girl, who had helped him before the race, and now served him cornbeer. Boys of the non-Inca population held the race in October, when the Southern Cross and α and β Centauri have their lower culminations at midnight and when feasts, apparently in honor of Mama Anahuarque ("mother

Anahuarque"), were celebrated. Boys of Inca nobility repeated the same ritual in December. Given the importance of Anahuarque, both as a mountain and as a female ancestral deity, in initiation rituals and in myths about human fertility, and given the important role that girls played during this phase of the rituals, I believe that a translation of the Aymaran name *anahuarque* proposed in 1976, which expressed a concept of "bringing boys and girls together in preparation for marriage," is still a valid suggestion.[31]

The Huarochirian myth of the celestial llama describes her as a constellation that circles around the center of the sky, as a goddess who saves the world from the Flood during her lower culmination at midnight by drinking its waters, as a mother who suckles her baby when she has risen but her baby is still below the horizon, and, finally, as one who favors men who worship her by giving them llamas and wool of many colors.

Various data from Cuzco can be compared to data from Huarochiri. Polo de Ondegardo mentions two stars close together, called *Catuchillay* and *Urcuchillay*, that represent a llama and her young. He does not identify the stars, but the modern knowledge in Southern Peru of the celestial llama does not make it difficult to recognize α and β Centauri. He refers to Vega in the constellation of Lyra as a male llama of many colors. Whereas, in Huarochiri, men received multicolored wool and llamas from a celestial black female llama, in Cuzco, the multicolored wool and male llamas were identified with a star.[32]

The best possibility for obtaining calendrical data from this comparison is provided by certain ritual data of Cuzco. In Huarochiri, the celestial black llama prevents the flood in October by drinking all the waters. In Cuzco, Anahuarque saved people from the flood by rising with the waters. The chroniclers mention that the non-Inca boys commemorated the event in October, that is, in the Inca month equated with the month of October in the Christian calendar. Then, people would bind a black llama to a pole on the plaza, depriving it of food and water, causing it to weep. In this way the black llama was thought to beg for the coming rains. Comparing both types of data reveal an ambivalent attitude toward the rains. On the one hand, people feared that too much rain would flood the country, but on the other hand they needed the rain to make their crops grow. This ambivalence allows us to compare the function of the black llama in Cuzco to that of the celestial black llama in Huarochiri.[33]

From this data, we can argue that the *ceques* of *suyu* IV accounted calendrically for the period from 3 September, when the sun had passed

the southern pillar on Picchu, to 21 November, when the Pleiades had started their heliacal set during the night. First, let us realize that[34] (1) the period of lower culmination for the Southern Cross, extending from its first heliacal set to its last heliacal rise, is (in A.D. 1500) from about 3 September to about 29 September, (2) the period of lower culmination for β and α Centauri is from about 7 October to about 2 November and (3) the period of upper culmination for the Pleiades, that is, from their last heliacal rise to their first heliacal set, is from about 5 November to about 18 November.

The question becomes: Which social group in Cuzco took care of which group of *ceques* in IV for what calendrical purpose at what time? The *ceque* system tells us which group of three *ceques* is associated with which of the ten groups of descendants of former Inca kings and two groups representing the non-Inca population. But only in one case, that of one of the non-Inca groups, do we know which period they were in charge of. The non-Inca people were calendrically represented in the valley by the towns of Sañu (San Sebastian) and Uma (San Jeronimo). These, as parishes of Cuzco, still participate in Cuzco's Catholic festivals. Uma celebrated its initiation rituals in the month of Umaraymi, which the Spaniards identified with October. The Aymaran name *uma* ("water") suggests the interest that the town of Uma, indeed, all the people of the valley, had in the water rituals involving a black llama at the time when the celestial black llama had her lower culmination.[35]

Ceque Anahuarque, which belonged to Cuntisuyu (*suyu* IV) and was worshiped by the non-Inca people, was involved in the observation of the risings of the Southern Cross and of β and α Centauri, which were of greatest interest to Andean peoples during the periods of their lower culminations. This suggests that, in the *ceque* system, the sequence of ritual attention to the *huacas* in *suyu* IV followed the observation of these two constellations. The following correspondences could be made: between the 28 *huacas* of *ceques* IV_B 3 b through IV_B 2 a and the motion of the Southern Cross, between the 30 *huacas* of *ceques* IV_B 1 c through IV_A 3 a, c and the motion of β and α Centauri, and between the 22 *huacas* of IV_A 2 c through IV_A 1 a and the motion of the Pleiades.

This argument was based only on data related to the Southern Cross and to α and β Centauri; evidence that was independent of the argument based on data related to the Pleiades. Now we can combine these two types of evidence and place the sidereal lunar year of 328 days within the solar year. Data concerning the Pleiades suggest a parallel between their period of visibility and the *ceque* system as a period of 328 days. The

data concerning the Southern Cross and α and β Centauri not only confirm their calendrical function, but also give the necessary evidence for linking the calendar to the *ceque* system as a sociopolitical system. Both groups of data, from the Pleiades and from the Southern Cross and α and β Centauri, support each other best with a beginning date for the sidereal lunar count of 9 June.

The result obtained also reveals the importance of other calendrical data included in the *ceque* system. I will mention two here. First, the division of *suyu* IV into IV_B and IV_A was tied to the date, 15 October, of the lower culmination of α and β Centauri at midnight, confirming the importance that the mythology of Huarochiri gave to this event. Second, the *ceque* system measured the complementarity and opposition of the constellations of the "eyes of the llama" and the Pleiades, since the period of upper culmination of the latter follows immediately upon the lower culmination of the first. We are now in a position to analyze the word *catachillay*, which referred to both.

CATACHILLAY

Polo de Ondegardo was familiar with the *ceque* system—where the information on *huaca* Catachillay appeared—and its calendrical function at least by 1567.[36] He called a celestial llama Catuchillay (probably a misspelling of Catachillay) in a publication in 1584 based on his earlier papers.[37] It is, therefore, reasonable to expect that his informants on Cuzco, in 1567 or before, were familiar with that single term for the two constellations. This double reference is clearly stated in Bertonio, although he also repeats a mistake made by secondary authors after Polo. Bertonio, has the following Aymaran data:[38]

Little goats ("cabrillas" in Spanish for Pleiades) as are called some small stars *Catachilla huarahuara.*
(*huarahuara* star, this is not a double name [Bertonio's text])
Catachilla a nebulous star in the Milky Way, and the stars upon the nebulosity.
Cross, the stars *Unuchilla catachilla.*

Bertonio calls the Southern Cross Catachilla, as does the anonymous Quechuan dictionary edited in 1586 by A. Ricardo.[39] There are three good reasons to argue that they confused the Southern Cross—which was, at that time, much used by European navigators—with α and β

FIGURE 6. A cosmological drawing by Santacruz Pachacuti Yamqui,[19] p. 226, representing Coricancha. (Photograph of a microfilm copy of the manuscript.) For an analysis of the schematic structure of the drawing and a comparison to Urton's Andean star map, see Zuidema and Urton,[10] pp. 61–67, 109–10 and Urton,[2] ch. 7.

Centauri and that Polo was correct in his identification of the celestial llama as Catachillay. (1) In Huarochiri at the end of the sixteenth century, the dark cloud constellation in the Southern Cross was referred to as Yutu ("partridge"), as it is known today.[40] (2) In his 1613 drawing, the indigenous chronicler Santacruz Pachacuti Yamqui showed a cross of four stars, calling it Chacana, with a fifth star to the left that he calls Catachillay. Although he adds the words "in general" to Chacana, implying that there are other constellations called *chacana* ("cross"), the Southern Cross was one of them and he makes it clear that Catachillay was not[41] (FIGURE 6). (3) The third reason derives from Bertonio's own data. Here I have had to clear up two confusions in Polo's text. First, one reads that the two stars of the celestial llama and her young are close to the star of the male llama, although clearly we should read that the first two stars are close to each other. They do not have to be near Vega; in fact they are not. A minor mistake is that Polo calls α and β Centauri the mother llama and the baby llama, respectively, although these stars are the eyes of the mother. The second confusion is that Polo gives the male llama and the baby llama the same name, Urcochillay.[42] *Urco*, in both Quechua and Aymara, refers to a "male animal," more specifically, a "male llama," and is not used for a young one. Bertonio's dictionary includes the following words:[43]

Unu	only one, alone
Unumalla	a beloved, only child

Taking the other translation of *catachilla* into account, it is likely that Bertonio's constellation *unuchilla catachilla* refers to the baby llama and its mother llama as a group of "nebulous stars." "Young llama" in Quechua is *uña* and it is possible that one of Polo's copyists misread the Quechua name (Uñachillay) of the celestial baby llama, giving it the father's name (Urcochillay).[44]

Most likely, then, Bertonio wrongly identified *unuchilla catachilla*. Neither identification, Southern Cross nor α and β Centauri, affects my argument for these constellations' astronomical and calendrical importance. They rise at the same place and one constellation directly follows the other. However, the recognition that *unuchilla catachilla* represents the baby llama and her mother supports the argument that Bertonio as well as Polo de Ondegardo used the term *catachilla* or *catachillay* for the Pleiades and for α and β Centauri and that they played a complementary role, as indicated by the *ceque* system.

I will end my argument now with an analysis of the terms *unu* and *cata* by which the two stars Unuchilla and Catachilla are distinguished. I will not consider the term *chilla* or *chillay* as used in the names of these stars; it probably just means "star." *Cata*, or *cati*, occurs in both Quechua and Aymara as a root of words with similar meanings, such as "dragging over the ground," "following him/her who goes ahead," "dragging, leading (a llama?) with a rope." The Aymara words *catari* ("viper") and *havira cata* ("the bed [in Spanish "mother"] of the river") are probably based on this root. Given that Urcochillay is a male llama star and Unuchilla a young llama star, we can see that *cata* is an attribute that the mother llama star has in common with Pachamama, the Earthmother. Another name of Pachamama, again in both Quechua and Aymara, is Suyrumama, "mother with the long dress that drags (over the ground or through the mud)."[45] In harvest rituals, women would imitate Pachamama, walking about with just such a long dress.[46] When the Quechua poem addresses the Virgin as *catachillay*, it is probably using "dragging," "carrying" as a common characteristic of female deities.

The meaning of the term *unuchilla* gives us an additional reason why the celestial llama was given such a name. From the Aymaran root *unu* are derived the following terms:[47]

unuqueatha	to move
unuqueña	movement
laccampuna unuqueñapa	the movement of the sky

If we accept a semantic relationship among these words and *unumalla* ("beloved, only child")—but this needs further analysis—and if, therefore, we argue that *unuchilla* refers to a "child star that follows its mother star," then we will notice a close correspondence to the description that the celestial llama and her child received in Huarochiri. She was said to circle around the center of the sky; in other words, she indicated the movement of the sky around the south celestial pole. When she rose, she suckled her child, which was still below the horizon, following its mother. It was the relationship between the two that allowed Andean peoples to discover that their observable movement in the sky around the south celestial pole continued below the horizon; this is especially obvious in October when they would set early in the evening and rise early in the morning during the same night.

CONCLUSIONS AND FURTHER PERSPECTIVES

The Pleiades had the name *catachillay* in common with α and β Centauri. Both constellations had the attribute of "carrying along." While the Centauran stars, belonging to the celestial llama, carried the baby llama around the center of the sky, the Pleiades, as the mother of the other stars, carried them along.

The Pleiades and the celestial llama have several attributes in common. They are female, they are worshiped especially by herders, and they are related to water. The Pleiades are called the "swimming ones;" they give their name to a *huaca* that is a spring, Catachillay, and they are implied in a myth about a spring, Susurpuquio. The celestial llama prevents the Flood by drinking water from springs. Other Andean myths recount how llamas created springs by disappearing into the earth and how a female *huaca* as a deity created women and—presumably female—llamas from a lake.[48]

In Cuzco, a ritual was carried out in April in which the Inca king and a white llama with a red cover over her back would sing to each other, saying *yn yn*, imitating the singing of the rivers.[49] This llama, too, was tied to a pole on the plaza, where she was given cornbeer to drink and where she was expected to kick over a vessel of beer with her feet.[50] Other information allows us to link these data to the astronomical observations of the sun passing through the pillars on Picchu in April. We notice a clear opposition between two rituals in October and April, half a year apart. In the first, a black llama is starved; in the second, a white llama is "force-fed."[51] The two rituals depend on the observation of the lower culmination of the celestial llama (October) and the zenith passage of the sun (30 October) and on the observation of the last heliacal set with lower culmination of the Pleiades (15 April and after) and the nadir passage of the sun (25 April), respectively.[52]

A question to be answered at greater length in the future is, Why are the Pleiades and α and β Centauri connected so strongly to water and to llamas?[53] An answer to the first part of the question was given in a earlier article. The celestial llama not only moves in the Milky Way—*Mayu* ("river")—and prevents the Flood by drinking water, but she also gives birth after first releasing her amniotic waters. The motif of birth in relation to llamas also suggests why this animal was chosen in relation to the Pleiades, their period of visibility, and the sidereal lunar calendar. The

gestation period of llamas is eleven months, about the same length as the two other periods. The agricultural cycle from August to April or from September to May, depending upon the actual situation in a year of the nine synodic months used, was compared to the pregnancy of the Earth-mother and, thus, to the human gestation period. A comparison of the sidereal lunar cycle of 328 days with the llama gestation period—of the animal that so much supports human exploitation of the Andean habitat—fits within such a scheme.

In this article I concentrated on the problem of *catachillay* as a name for both the Pleiades and the celestial llama, the eyes of which are α and β Centauri. An analysis of Inca and Andean calendrical rituals depends upon a proper understanding of the sidereal lunar calendar and its precise place in the solar year, a place that was obtained by observing the lower culminations of these two constellations. The word *catachillay* identifies them in their complementary roles.

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9. See Zuidema.[8] The terms "heliacal rise" and "heliacal set" are used as defined by Anthony F. Aveni, "Astronomical Tables Intended for Use in Astroarchaeological Studies," *American Antiquity*, vol. 37 (1972), pp. 531–39, where he gives the following definitions:

A. The first day on which a star is visible in the east before dawn.
B. The last day on which a star is visible in the west after sunset.
C. The last day on which a star is seen to rise after sunset.
D. The first day on which a star is seen to set before sunrise.

With the help of these definitions, we distinguish four successive periods in the yearly cycle of a star:

A–C. A star is seen rising at or near the eastern horizon at an earlier time each successive night.
C–D. A star is observed during the whole night, as it is visible at dusk and at dawn. No horizon observation is made.
D–B. A star is seen setting at or near the western horizon at an earlier time each successive night.
B–A. A star is invisible.

A star has its upper culmination at midnight within the period C–D, and its lower culmination at midnight within the period B–A. While there are no bright stars near the celestial south pole that are visible at all times on all nights in Peru – Cuzco is at a latitude of 13° 30′ south of the equator – Andean peoples were interested in some stars, α and β Centaurus and the Southern Cross, for instance, that are visible at some time of the night every night. I discuss this particular case in the next paragraph.

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12. DIEGO GONZALEZ HOLGUIN, *Vocabulario de la lengua . . . Qquichua . . .* (1608; rpt. Lima: Imprenta Santa Maria, 1952), see URTON,[2] pp. 113-14, 200.
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16. EL INCA GARCILASO DE LA VEGA, *Comentarios Reales* (1609; rpt. Buenos Aires: Emecé, 1945), Book 3, ch. 20-22; GRAZIANO GASPARINI and LUISE MARGOLIES, *Arquitectura Inka* (Caracas: Universidad Central de Venezuela, 1977), pp. 229-42; OSCAR LADRÓN DE GUEVARA, "La Restauración del Coricancha," *Revista del Museo e Instituto Arqueológico*, vol. 21; J.H. ROWE, *An Introduction to the Archaeology of Cuzco, Papers of the Peabody Museum of American Archaeology and Ethnography*, vol. 27-2, (1944); pp. 29-33.
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18. See ZUIDEMA,[8] and the other authors mentioned in the same note.
19. See MOLINA,[17] pp. 20-21; JOAN DE SANTACRUZ PACHACUTI YAMQUI, *Relación de Antigüedades de este Reyno del Perú* (1613; rpt. Asunción del Paraguay: Editorial Guaranía, 1950), pp. 237-39.
20. R. TOM ZUIDEMA, "La Imagen del Sol y la Huaca de Susurpuquio en el Sistema Astronómico de los Incas en el Cuzco," *Journal de la Société des Américanistes*, vol. 43 (1974-76), pp. 199-230. In this article I brought together the different versions of this myth, but I cannot now maintain the location of Susurpuquio I suggested there.
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23. I thank Mr. Bruce Mannheim for his permission to use this verse of the poem that he will analyze in a future publication.
24. See COBO,[4] book 13, ch. 6.
25. See POLO,[14] pp. 3-4.
26. *Quespi* as "crystal" etc., see GONZALEZ HOLGUIN;[12] *Quespilla casilla* as a term of address to Pachamama, see MOLINA,[17] pp. 42-43, 74-75; *Casi* and *casiui pakhsi*, see BERTONIO;[13] August addressed as *quispi*, see MOLINA,[17] pp. 28-29. The month Haocay cuzqui, which began "in the middle of May," was identified by Molina as "May," but by almost all other chroniclers—especially those who wrote after the introduction of the Gregorian calendar—as "June." I follow here the general usage. For this reason I identify the month that Molina calls "July" as "August."
27. See PEREZ BOCANEGRA,[21] pp. 132, 152; see ZUIDEMA and URTON,[10] pp. 73-74.

28. See URTON,[2] pp. 169–73, 185–88; see ZUIDEMA,[14] pp. 136–39.
29. See ZUIDEMA,[4] pp. 4, 93, 134–37, 222, 241; see ZUIDEMA and URTON,[10] pp. 75–85; see MOLINA,[17] p. 54; MARÍA ROSTWOROWSKI DE DIEZ CANSECO, "Nuevos Datos Sobre Tenencia de Tierras Reales en el Incario," *Revista del Museo Nacional*, vol. 31 (1962), pp. 137–38, 153–57.
30. See AVILA,[11] ch. 29.
31. See ZUIDEMA and URTON,[10] p. 85.
32. See POLO,[14] pp. 3–4.
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37. See POLO.[14]
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41. See SANTACRUZ PACHACUTI YAMQUI,[19] p. 226. See FIGURE 6.
42. See POLO,[14] pp. 3–4.
43. See BERTONIO.[13]
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Astronomy and Calendrics on the Coast of Peru

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THE "TRADITION" of archaeo-ethnoastronomical studies that has developed in recent years in Peru[1] has centered on the astronomical and calendrical systems of the Incas and the contemporary Quechua-speaking Indians of the Department of Cuzco. Whether the focus has been on pre-Columbian or contemporary times, the principal concern has been with understanding the calendrical systems that were adapted to the rugged, essentially vertical Andean world. Our studies of Quechua astronomy in the highlands reflect a pattern of the correlation, within a single calendar system, of a wide range of natural cycles pertaining to a variety of ecological zones and astronomical phenomena. However, one would expect that highland Peruvian calendrics would differ in some respects from the calendrics of the coast. Along the strip of dry coastal desert, resources vary horizontally (i.e., the alternation of stretches of desert and river valleys). As one moves eastward toward the nearest range of coastal mountains, the horizontal variation gives way slowly to the highland pattern of vertical variation. Therefore, one would, perhaps, expect to find significant differences between highland and coastal calendrics, given the respective vertical and horizontal variation in the distribution of resources. However, it is also reasonable to expect some blending or convergence of traditions with regard to the astronomical periodicities encoded in the calendar systems of these two regions given the fact that the coast and the highlands lie within the same latitudinal boundaries.

The coast of Peru stretches from 3° to 18° south latitude and between 70° and 81° west longitude. There are a number of environmental and climatic differences along the coast from the extreme north to the ex-

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treme south; in general, the coastal strip is characterized by an increasing dessication as one moves from north to south. On the north coast, for instance, the Moche valley receives an annual precipitation of 0.5 cm, primarily in the form of winter season mists; the lack of precipitation on the south coast is even more extreme. The aridity of the coastal environment is a result of the cold northward-flowing Peru (or Humboldt) Current, which cools and dessicates the prevailing southwesterly winds. The cool air is condensed, then warms up as it passes over the coastal desert. The warmer air results in fog, particularly prevalent during the winter, which is deposited not along the coast but rather along a "fog belt" on the western slopes of the coastal mountain range. The fog belt supports a seasonal, highly specialized vegetation called the lomas.[2] Concerning the seasonality of the lomas: "The temporal availability of lomas products was irregular. . . . The microcyclic or seasonal bloom of the lomas stands extends from about July to November, with various products becoming accessible at different times. . . . However, by December the lomas completely disappear and the stands revert to desert."[3] The extent of the lomas vegetation during pre-Columbian times, and the degree to which it was actively exploited by early populations, are matters of some debate, but it is clear that its resources and seasonality had a significant effect on the subsistence strategies of coastal populations.

Another seasonal factor in the subsistence systems on the coast is the periodic change in the amount of water available in the numerous rivers that descend from the coastal mountain range and flow across the dry coastal desert. As these rivers run full only during the summer months (December–March), their seasonality represents a periodicity that has been of considerable importance to survival along the coast. With the development of intensive irrigation agriculture along the coastal river valleys, which began between 2000 and 1500 B.C.,[4] the temporal variations in the amount of surface water were an increasingly important cycle for incorporation in the coastal calendar systems.

The most stable food source, although not the most abundant,[5] throughout the long history of human occupation of the Peruvian coast derives from the sea. Marine fish and shellfish, in addition to shorebirds, appear in the refuse of shoreline fishing villages beginning around 12,000–10,000 B.C. Variations in what is referred to as "microcyclic" availability of marine foods is a subject of some controversy. In general, we can accept Moseley's observation that ". . . most near-shore fish, seafowl, and algae are available throughout the year . . . ," but must reject *his further* qualifying statement that the availability of these resources

was not subject to significant microcyclic fluctuations. Moseley's observation is insupportable in light of recent studies;[5] but, more importantly, very few intensive studies have been carried out on the biological and tidal (e.g., diurnal, semi-diurnal, lunar, semi-lunar) rhythms of marine fauna and flora off the Peruvian coast.[6] From comparative studies,[7] we know that calendars that integrate biological and lunar/tidal cycles are extremely complex and, until we know more about the tidal and marine biological rhythms off the Peruvian coast, we cannot assume that minor fluctuations did not exist and did not serve as important temporal markers in the calendars that were adapted over time to the coast of Peru.

From the above description, we are provided with two ways of seeing astronomy and calendrics on the Peruvian coast. First, the cycles that were first organized in coastal calendar systems were no doubt those which were of most immediate, local importance in securing a livelihood. This would have included such periodicities as marine cycles, the seasonal flowering of the lomas, and seasonal differences in the amount of fresh water available in the coastal river valleys. In the historical development of coastal cultures, the local calendar systems that developed within each river valley would have been subsequently integrated, through trade, pilgrimage, and so on, with other such systems operating within adjacent and distant valleys. Second, as coastal, marine-oriented groups began to exploit resources further up the coastal valleys with the development of irrigation agriculture, one would expect the appearance of some rather complex transitional systems adapted to a wider range of subsistence activities combining fishing, gathering, and intensive agriculture within multiple ecological zones. For example, I would suggest that the lines on the plain of Nazca may reflect such a transitional system and that the complexity of this system may derive from the integration of coastal and highland patterns of calendrics, astronomy, and agricultural organization.[8]

In constructing a hypothesis for the calendrical organization of activities on the coast and suggesting how observations of celestial phenomena were integrated into the calendar, we can best begin by outlining the contemporary calendars operating within this zone and compare these temporal patterns and observational data with those that may have existed in pre-Columbian times. To be clear from the outset, we are not proposing that purely indigenous calendars are still used on the coast. Since the time of the Spanish conquest, there have been tremendous changes in the utilization of the coastal valleys for

agricultural purposes. The impact of Spanish culture and the wholesale extermination or replacement of the aboriginal population has been much more complete on the coast than in the sierra, although there are still small fishing villages in which limited knowledge of the pre-Spanish languages of the coast survive.[9] Despite the disappearance of the aboriginal populations and the introduction of new crops and capital-intensive, mechanized farming practices, there are certain elements of continuity, especially in terms of environmental factors, which constrain the contemporary economy just as they did in the pre-Columbian period.

It should be pointed out that, in addition to the same environmental setting and the same subsistence system, the coastal farmers and fishermen today are exposed to the same astronomical phenomena at the same times of the year as the pre-Conquest populations. Therefore, we would expect that stars used in navigation by fishermen off the coast of Peru, whether the fishermen are Indian, mestizo, or Spanish, are not stars related to navigation in some other part of the world (e.g., Spain), but rather are those stars and constellations which are most efficient for determining one's bearings in traveling to and from good fishing locations off the Peruvian coast at different seasons of the year.[10]

In the traditional fishing village of Huanchaco, located on the north coast in the Moche valley, there are fishermen who consider themselves descendants of the Chimu, the people who occupied the Moche valley at the time of the Spanish conquest. Just offshore, these fishermen still fish in caballitos (small reed boats); farther out at sea, they fish in both sailboats and small motorized craft. If we suppose that the modern-day location and periodicity of shoals of fish off the north coast are similar to their location and periodicity in pre-Columbian times, we would expect that the contemporary system of navigation would be very similar to that of the Chimu fishermen who worked these waters during pre-Spanish times. As for contemporary navigational and fishing techniques:

> The knowledge of the sea . . . is acquired during apprenticeship and by direct experience, such as with the recognition of the appearance of shoals of fishes. This is related to the movements of the moon, the seasons of the year, the coloring of the waves, the temperature of the water and the air, the relative position of stars in the sky, and the debitage that has been cast up on the beach.[11]

In 1944, John Gillin undertook six months of ethnographic fieldwork in the communities of Moche and Huanchaco,[12] both of which are located in the valley of Moche. The Moche fishermen use no watercraft,

and all fishing is done either from the shore, in the Moche river, or in the irrigation ditches. The only offshore fishing done by the Moche fishermen is during the summer months (November to May) when fishing boats from the village of Huanchaco pick them up and the two groups fish together in the waters off Moche. The fishermen of Huanchaco are important for this study because of their deep-water fishing techniques and navigation by astronomical orientations. Huanchaco is thought of as a "Moche" village. The Moche (or Mochica) occupied the north coast before the Chimu, who were their descendants. The center of the Moche kingdom was in the Moche valley, although their influence, as evidenced by the archaeological record of the distribution of Moche-style art, architecture, and pottery, covered much of the north coastal area during the period from about 200 B.C. to A.D. 600.

The villagers of Huanchaco are primarily fishermen, although they also cultivate land inland from the village. Gillin has provided a good description of the fishing paraphernalia and practices in Huanchaco, but I will concentrate here on the astronomical knowledge he records. The best fishing months off the coast of Huanchaco are from late November to early June. During this period, the fishermen either fish off the waters in front of the Moche valley or fish much farther out at sea. During the best fishing season, the boats leave at noon and stay out all night.

> The boats stay out at sea . . . until dawn of the following morning. . . . Time is kept by the stars. For example, according to Felipe Carranza, the *Lucero de la Mañana* appears in November at about 4 a.m.; *Las Cabrillas* (Pleiades) about 3 a.m.; and *El Arado* sets between 3 and 4 a.m., at about the same time that the *Cruz de Mayo* appears. When these astronomical signs show that the hour is between 3 and 4 o'clock in the morning, the boats begin to return to port. Usually the boats are out about 16 to 20 miles. . . .[13]

There are several problems with Gillin's description of the astronomical observations made in November. First, he says that the *lucero de la mañana* rises at about 4 A.M. in November. In Spanish, *lucero* refers specifically to Venus as the morning-star. However, in November 1944 (the year of Gillin's fieldwork), neither Venus nor any other planet appeared as the morning-star.[14] Therefore, the *"lucero" de la manana* was probably a bright star, perhaps Regulus or Spica.

Second, Gillin says that the Pleiades (*las cabrillas*—"the little goats") rise in November at about 3:00 A.M., but, in fact, they set just before sunrise and rise just after sunset at this time of the year.

Third, the statement that *el arado* ("plow") sets between 3 and 4 A.M. is difficult to interpret because Gillin does not identify the constellation. In highland Quechua astronomy, the "plow" is either the constellation of Scorpio or the Big Dipper.[15] In November, the Big Dipper rises about 3 A.M., while Scorpio rises at about the same time as the sun. With the limited description at hand, therefore, it is impossible to choose one identification over the other.

Fourth, Gillin says that the *cruz de Mayo* ("cross of May") appears between 3 and 4 A.M. Cruz de Mayo is not, to my knowledge, a European, Spanish, or Andean constellation.[16] Since the villagers of Huanchaco celebrate the festival of Cruz de Mayo (the Invención de la Santa Cruz) on 3 May, I suspect that an indigenous "cross" constellation was given the name of the principal Catholic festival devoted to the cross (the Cruz de Mayo of 3 May). As the Southern Cross rises just before sunrise in mid-November, and rises at sunset in late April, I would tentatively identify this constellation as the Cruz de Mayo. When we recall that the period from November to late May is the period of the best fishing off Huanchaco, it is clear that the Southern Cross could represent an important constellation in the coastal fishing calendar. It should be noted as well that *las cabrillas*, the Pleiades (at right ascension 3 hr 40 min), are located opposite the Southern Cross (R.A. 13 hr 30 min); therefore, the appearance and disappearance of these opposed constellations can be observed together to time the best fishing season off the coast of Moche.

Having discussed some of the astronomical phenomena observed by the fishermen of Huanchaco during the month of November, we can look more closely at the calendrical periods and saints' days associated with the fishing cycle, and conclude this section with an outline of the combined fishing and agricultural calendar on the north coast.

The best months for fishing in the waters off Huanchaco are from late November to early June. During the months from July to October, the fishermen of Huanchaco fish to the south of the Moche valley, in some cases going as far south as the Santa river. There are three principal festivals celebrated during the year in Huanchaco. The festival of San Pedro, patron saint of fishermen, is celebrated on 29 June, a time when there is relatively poor fishing in the area of Huanchaco. Secondly, the village has a cross cult and celebrates the Invención de la Santa Cruz (Cruz de Mayo) on 3 May. The third major festival takes place once every five years when La Virgen de Socorro, who is said to take a special interest in the village of Huanchaco, is taken on a pilgrimage from Trujillo to Huanchaco. The pilgrimage begins on 30 November, the day of San Andrés, and arrives in Huanchaco on 24 December.[17]

I will hypothesize that the three festivals celebrated today in Huanchaco are the result of the syncretism of Spanish Catholic festivals with local, pre-Spanish celebrations related to the beginning and ending dates of the fishing and agricultural cycles as they are timed by the heliacal rise and set of the Pleiades. As for the importance of the Pleiades, Gillin states that they are observed by fishermen in November, but we know as well that the Pleiades were important in this area during early colonial times. In 1638, Antonio de la Calancha published an account of the history and beliefs of the indigenous population in the Pacasmayo valley, which is north of the Moche valley. These people, the direct descendants of the Chimu, spoke a language called Yunga by the Quechua-speaking Indians of the highlands.[18] In the language of the Yungas, the Pleiades were called Fur:

> They [the Chimu] do not count the year by Moons, nor by the course of the Sun, but rather from the rise of the stars which we call the *Cabrillas* [the Pleiades] and which they call Fur. The reason for this is found in a long fable, which is none of my concern. It was a law that they counted the year thusly, because these stars gave them food and nurtured their crops, for their livelihood, therefore, they had to begin the year from the time they saw it appear and it gave them sustenance.[19]

If we accept that the Chimu year was calculated by the heliacal periodicities of the Pleiades, how does this relate to the saints' days celebrated today in the village of Huanchaco? The Pleiades begin to rise at sunset on 18 November. They then undergo heliacal setting (at dusk) on 19 April, are invisible for about 45 days, and reappear in the east in the early morning of 3 June. Therefore, the rise of the Pleiades just after sunset near the day of San Andrés (30 November) marks the beginning of the good fishing season and their heliacal rise in the early morning hours of 3 June marks the approximate end of the good fishing season. If we combine the fishing cycle with the agricultural cycle in the Moche valley, we will arrive at a better understanding of the 45-day period of disappearance of the Pleiades from late April till early June.

The Mocheros plant and harvest two crops a year. The "wet season crop" is planted in early December and harvested in May; the harvest festival is celebrated on the day of San Isidro (15 May). The "dry season crop" is planted in early June and harvested in October; the harvest festival of this crop is on the day of the festival of Cristo Rey, on 22 October.[20] If we combine the agricultural and fishing cycles, we find that their boundaries closely correspond to the heliacal rising and setting times of the Pleiades as outlined above (FIGURE 1).

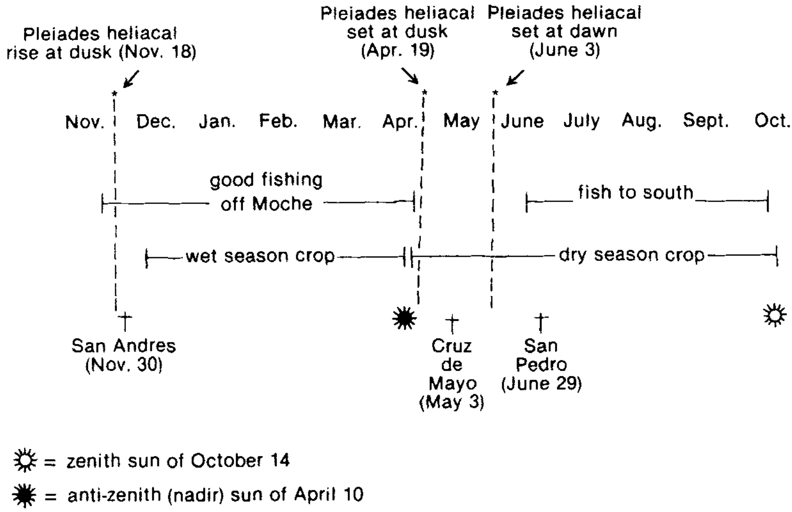

FIGURE 1. Moche/Huanchaco calendar.

In FIGURE 1, I have included the periods of the fishing cycle, the two agricultural cycles, the rising and setting periods of the Pleiades and the dates of one zenith and one nadir passage of the sun. The importance of the latter two dates will be discussed later. I would suggest that FIGURE 1 illustrates well Calancha's statement that the Pleiades were thought by the Chimu of the north coast to be responsible for their livelihood. The periods of transition in the various subsistence activities are correlated rather closely with the times of the heliacal rise of the Pleiades (at both dusk and dawn).

It may be hypothesized from FIGURE 1 that, in the process of syncretizing the Spanish Catholic calendar of saints' days with the indigenous calendar based on the Pleiades, San Andrés correlated well with the heliacal rise at dusk of the Pleiades; the period from Cruz de Mayo to San Pedro was associated with the period from the disappearance of the Pleiades until their heliacal rise at dawn in early June. It should also be recalled here that, as mentioned by Gillin, Cruz de Mayo refers to a constellation, probably to the Southern Cross. As I have mentioned, the Southern Cross and the Pleiades are in opposition to each other and, therefore, as the Pleiades set at dusk (on 29 April), the Southern Cross set at dawn (13 April). I would suggest that, in the indigenous calendar of the Chimu, the transitional period related to the end of good fishing, the harvest of the wet season maize crop, and the planting of the dry season

crop, was bracketed by the period from the heliacal rise of the Southern Cross until the heliacal rise of the Pleiades.

In FIGURE 1, I included the dates for one zenith and one nadir (i.e., midnight nadir) passage of the sun. From our research on Andean astronomy, we know the importance of the zenith and nadir passages of the sun in connection with the agricultural calendar.[1] I will suggest that the same was, and still is, true in the agricultural calendar of the north coast. The village of Santiago de Cao is located at 7° 40′ south latitude in the delta of the Chicama river, the next major river valley north of Moche. The agricultural cycle in Santiago de Cao has been studied and described extensively by Jose R. Sabogal Wiesse.[11] The single crop of maize produced today in Santiago de Cao is planted in March and harvested 5½ months later. The agricultural cycle, from planting to harvesting, is correlated with the phases of the moon. The timing begins with a series of injunctions concerning the time to plant and harvest:

a) plant during the month of March
b) plant maize just after the new moon; some say 3–4 days after, some say 6–7 days. In general, maize should be planted during the waxing moon; it is bad to plant during the waning, fourth quarter of the moon
c) Maize should be planted on, or by, Domingo de Ramos, the Sunday before Easter
d) Maize matures in 5½ months and should be harvested during the full moon.[21]

The only date that is "fixed" in the series of injunctions concerning the time to plant is the date of Domingo de Ramos (Palm Sunday). However, Domingo de Ramos itself is not actually a fixed date since it is celebrated on the Sunday before Easter, and the latter is celebrated on the Sunday after the first full moon after the equinox of 21 March. Since Easter can fall anytime during the period from 22 March to 25 April, Domingo de Ramos falls one week earlier (i.e., from 15 March to 18 April; the full moon always comes between Domingo de Ramos and Easter. If the campesinos of Santiago de Cao say to plant maize during the waxing moon and to be finished planting by Domingo de Ramos, the new moon at the beginning of the planting cycle will move through the calendar eight days before Domingo de Ramos and fifteen days before Easter. Therefore, the actual date of planting, the new moon associated with the March equinox, will vary between 7 March and 10 April (i.e., 22 March to 25 April minus fifteen days, one-half a lunar cycle.

If we assume that the dates for planting maize in Santiago de Cao,

from 7 March to 10 April, were also the dates for planting the principal maize crop in pre-Columbian times, how would the boundaries of this period have been reckoned in the indigenous calendar? I will hypothesize that the dates of the zenith and nadir passages of the sun were important in the coastal agricultural calendar. At a latitude of 7° 40′ south, the sun passes through the zenith of Santiago de Cao on 12 October and 3 March, and it passes through the nadir point at midnight on 9 April and 7 September.

As the sun (apparently) moves northward toward the equinox of 21 March, it passes through the zenith of Santiago de Cao on 3 March (near the 7 March limit of the planting new moon), and continues its journey until it stands in the nadir at midnight on 9 April (very near the 10 April boundary date of the planting new moon). Therefore, if maize is planted on the new moon that falls between the zenith sun of 3 March and the nadir sun of 9 April, the maize planting will always occur during the waxing moon and will, therefore, be completed (in the calendar in use to-day on the coast) by Domingo de Ramos.

If we return now to FIGURE 1, we can suggest, as a possible corrolary of the relationship between the agricultural cycle and the zenith/nadir sun in Santiago de Cao, that, in the Moche valley, the zenith sun of 14 October may be used to time the harvest of the dry season crop and the planting of the wet season crop. The nadir sun of 10 April is rather far from the time of either harvest or planting, but we may hypothesize that its observation could have been important in timing the synodic cycle used in planting the dry season crop.

Before leaving this discussion of astronomy and calendrics on the north coast and turning our attention to the central coast, we should mention the other Chimu astronomical data given by Calancha. The Indians of the north coast worshiped the Moon (Si) over the Sun. At the new moon, the Indians said that the moon had gone to the underworld to punish thieves and that it was aided in this work by six stars, two of which, collectively called Pata, were the outer stars of Orion's belt. Pata holds the middle star, which represents a thief, captive. The moon orders Pata to turn the thief over to be eaten by four vultures, represented by four (unidentified) stars below Orion's belt.[22] Finally, Calancha says that the Indians of the coast took as their progenitors four stars, two of which begat the nobles, the other two of which begat poor people. The four ancestral stars were sent by the creator god Pachacamac.[23]

That the various river valleys along the Peruvian coast were connected during pre-Columbian times by a web of political, trading,

pilgrimage, and other ties has been recognized for some time. It is apparent from both the archaeological and ethnohistorical record that interchanges were effected either along coastal land routes or by means of merchants and fishermen who plied the waters off the coast.[24] In addition, some of the valleys of the coast were related to each other by ties of kinship. We are made aware of the kinship ties among the central and south coastal valleys by a document written by Cristóbal de Albornoz around 1583. According to Albornoz, each coastal valley had its own set of *huacas* ("holy sites") which were worshiped by the Indians of that valley. The principal *hauca* of the coast was the large oracle/ceremonial center of Pachacamac, in the Rimac Valley. Another *huaca* mentioned by Albornoz was a star called Cundri, which was adored by the merchants of the valley of Chincha.[25] Given the importance of the Southern Cross in establishing orientations when traveling on the open sea off the Peruvian coast,[26] this constellation may well have been the stellar "holy site" worshiped by the Chincha.

At this poiint, I will indicate some future directions that our studies of coastal astronomy might take through an examination of the calendrical and astronomical data coded in one of the major bodies of myths pertaining to the central coast. The myths were collected in Huarochirí by Francisco de Avila.[27] Huarochirí is located about 100 km east of Lima at the head waters of the Mala river. The connection between the mountains and the coast is explicit in the mythology collected by Avila in Huarochirí.[28]

The creator/classifier god of Huarochirí was Cuniraya Viracocha. Cuniraya once visited the central coast, near Pachacama, in search of a young woman (Cavillaca) whom he had impregnated. Cuniraya arrived at Pachacamac and there found two young women, the daughters of Urpihuachac (according to Albornoz, Urpihuachac was the wife of Pachacamac). Cuniraya slept with the older daughter and just as he was about to sleep with the younger one, Urpihuachac appeared and converted her daughter into a dove who flew away. Now it happened at this time that there were no fish in the sea; the only fish that existed were kept by Urpihuachac in a small pond near her husband, the sanctuary of Pachacamac. Cuniraya was so angry at Urpihuachac that he tossed all the fish into the sea.[29]

Urpihuachac, the wife of Pachacamac, can be seen as a creator of both fish and doves.[30] In the language spoken in Huarochirí, Quechua, the word for "dove" is *yutu* (Sp. *tinamous*). In another section of his chronicle, Avila tells us that the people of Huarochirí had at least two "dark

cloud" constellations. One was a large black llama (Yacana) and the other was a small dark cloud that moved before the llama (Yutu).[31] The constellation of Yutu is the dark spot located at the foot of the Southern Cross.[15] I would hypothesize that, in the astronomy of Huarochirí and of the coast, the Southern Cross and Yutu represented, respectively, Urpihuachac and her daughter the dove. Given this, we would expect to find that the mother of fish and doves, the Southern Cross, was important to coastal fishermen and perhaps for timing the fishing season. In the discussion of the Chimu astronomical data provided by Calancha, we have seen the importance of the Pleiades as a creator constellation, and we have shown the opposition between the Pleiades and the Southern Cross. If we now argue that the Southern Cross may be identified as Urpihuachac, the mother of doves and fishes, how might she be related to the Pleiades in the mythology of Huarochirí? That the Pleiades were important in Huarochirí, and that they played a role similar to that found in the Moche valley (i.e., as the one who nourishes plants and animals) is indicated by the following passage from Avila:

> And when the Pleiades (*las Cabrillas*) appear very large, they say, "This year we are going to have an excellent ripening of the fruits," but when they appear very small they say "We are going to suffer."[31]

The creator of mankind in Huarochirí was the god Pariacaca, the principal god of the highlands and the coast. Pariacaca had six sisters, one of whom was called Chaupiñamca. Chaupiñamca and her five sisters were consulted as oracles by the people of San Pedro and other villages. As we have suggestions from elsewhere in the Andes that the stars of the Pleiades were considered to be a group (*qutu*) of young girls,[32] and as the Pleiades were observed (consulted) in divination and prognostications in Huarochirí and elsewhere, I would hypothesize that Chuapiñamca and her sisters were represented in the sky by the Pleiades. We have found in the data from Calancha that the rise of the Pleiades in early June and mid-November was important in the calendar of the Chimu. A parallel connection can be established in the mythological data from Avila.

After Pariacaca, the brother of Chaupiñamca, established himself as the principal god of the coast and the highlands, he instituted three festivals. He commanded that boys from the communities (*ayllus*) be given the responsibility for his worship. The boys were called *huacasas*. The times when the *huacasas* worshiped Pariacaca were determined by a group of old men (*yañcas*) from the *ayllu* of Cacasica. These old men were especially adept at making solar observations. A special wall was

constructed for observing the sun and when, from their place of observation, the sun arrived at the wall, the *yañcas* would indicate to the *huacasas* and the populace that it was time to go worship Pariacaca. People came for the celebration from the highlands and the coast. Three annual festivals were determined by the *yañcas*: (1) *Auquisma*: the festival of Pariacaca that was celebrated, in Avila's time, on Easter or Pentecost. (2) *Chaucosma*: the festival of Chaupiñamca that coincided with Corpus Christi, but which, Avila's informants said, was always celebrated in June in pre-Spanish times. (3) The festival of San Andrés, on 30 November, when they did a dance called Chanco.[33]

Before proceeding, we should note the heliacal setting and rising dates for the Pleiades:

18 November	The heliacal rise at dusk
19 April	The heliacal rise at dusk
3 June	The heliacal rise at dawn

And the dates of the zenith/nadir passages of the sun in Huarochirí (12° 10′ south latitude):

Zenith	16 February	Nadir	19 August
	26 October		22 April

As Avila says that Auquisma could be celebrated on either Easter (21 March–25 April) or Pentecost (49 days after Easter), it may be assumed that the date of celebration of the festival in pre-Spanish times was probably not a fixed solar date (or else it could have been syncretized with a fixed saints' day in the Catholic calendar); rather, it must have been a festival celebrated at a time that depended upon solar, lunar, and stellar periodicities. Given the importance of the full moon in determining the dates of festivals in the Andes,[34] and given the importance of the Pleiades and the zenith/nadir sun in Andean calendrics, I would hypothesize that the festival of Pariacaca (Auquisma), was celebrated on the first full moon after the heliacal set of the Pleiades (19 April) and the passage of the sun through nadir (22 April). The relationship of the dates of the celebration of Easter, Pentecost, and Auquisma are diagramed in FIGURE 2.

Concerning the date of the celebration of Chaucosma, Avila says that it is now celebrated at the time of Corpus Christi (29 May–1 July), but that earlier, in pre-Spanish times, it was celebrated in June. As I have argued above, the fact that the people of Huarochirí did not syncretize indigenous festivals and fixed saints' days in the Catholic calendar suggests that they were movable dates in the pre-Spanish calendar. For the

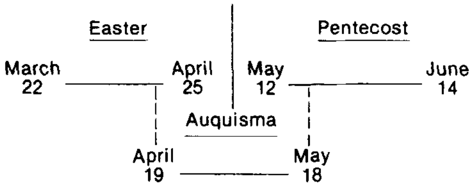

FIGURE 2. The calendrical correlation of Auquisma with Easter and Pentecost.

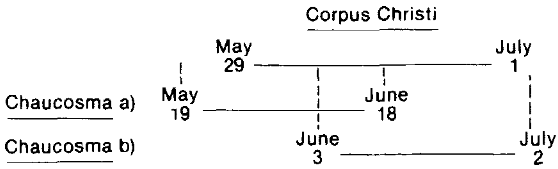

FIGURE 3. The calendrical correlation of Chaucosma with Corpus Christi.

date of Chaucosma, the festival of Chaupiñamca (the Pleiades), I would suggest either (1) the first full moon after Auquisma or (2) the full moon following the heliacal rise of the Pleiades on 3 June (FIGURE 3).

Having arrived at these hypothetical dates for the joint celebration of festivals by highland and coastal people, we can say that, since they are determined on the basis of the heliacal rising and setting dates of the Pleiades and on the basis of lunar periods fixed earlier in the year around the time of Easter, these dates correlate well with those discussed earlier for the calendar on the north coast. I would suggest, then, that these data and preliminary interpretations give us reason to investigate the ethnohistorical data more carefully in order to determine not only the calendrical cycles important in the integration of activities along the coast, but also those that were integral in correlating activities (e.g., pilgrimages, trading relationships, and subsistence activities) between coastal and highland communities.

In the preliminary study of coastal astronomy and calendrics presented here, several themes emerge that warrant further research.

First, in our description of the environmental cycles of the major resource zones of the coast (e.g., the seasonal bloom of the lomas and the periodicities of the most abundant river water and the best fishing), we have the seasonal boundaries that formed the "core" periodicities upon which more elaborate calendars, related to the exploitation of more diverse ecological zones, must have been integrated. It will be important

in the future to study carefully the range of environmental cycles between different coastal valleys and along individual rivers from the headwaters to the mouth, in order to determine the range of periodicities that would have had to be accounted for in local and regional calendars. A coastal society's ability to efficiently coordinate the resources and human activities of its river valley would have been a determining factor in the relative success or failure of its cultural tradition.

Secondly, one would suppose that, in the construction of large public or ceremonial structures, such as are encountered from the north to the south-central coast, orientations would have been chosen that related to celestial phenomena that rose, sat, or stood in the zenith at critical "boundary" times in the local and regional calendars of the populations serviced by those public or ceremonial buildings. From our study here, we are led to hypothesize that, along the Peruvian coast, the orientations incorporated in public architecture might include the rising and setting points of the Pleiades, the Southern Cross, Orion's belt, and the zenith and nadir sun (all of which will change with the latitude). In another study, Anthony Aveni and I have suggested that the zenith and nadir rising and setting points were important in the geometrical arrangement and astronomical alignment of the Nazca lines.

Finally, from our analysis of the ethnoastronomical data in the colonial documents and chronicles, it is clear that the ethnohistorical documents pertaining to different valleys or sections of the coast are important in the generation of hypotheses for investigating coastal astronomy and calendrics. The mythological data are particularly rich in this regard, but the coastal iconographic traditions may be equally important in providing orientations in the study of seasonal activities such as hunting and ritual.[35]

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Archaeoastronomy at Machu Picchu

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INTRODUCTION

In this paper, we will describe some of the results of an Earthwatch-sponsored expedition to study the old Inca citadel at Machu Picchu for sites of astronomical observation. The expedition took place in the summer of 1980; two groups of volunteers assisted the expedition leaders, Dearborn and White, in surveying and general data collection.

The Machu Picchu Citadel was chosen for this study because of its relatively unmolested condition. Unlike Cuzco, the Inca capital, the Spanish conquerors did not occupy Machu Picchu, and so did not have an opportunity to destroy this site of "pagan" worship. Perhaps even more significant is the fact that the citadel was voluntarily abandoned by its inhabitants. Since it was not continuously occupied, as was Cuzco, the original structures have not been pulled down to make way for modern buildings.

While our time at Machu Picchu was spent in a systematic routine of data gathering, there were two principle types of artifact for which we were searching. Our first interest was in finding structures or monuments designed for making precise astronomical observations associated with either an astronomically significant event (solstice, equinox, lunar excursion, etc.) or a cultural event. In addition, we hoped to find sites that may have been used for crude astronomical observations in conjunction with ceremonies.

While post-Conquest chroniclers leave us no direct information on Machu Picchu, their accounts do give us some idea of the observations that interested the Inca. Garcilazo de la Vega describes the preparations

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and ceremony attendant to watching sunrise on the day of the June solstice.[1] At Machu Picchu, we have found a structure that is well designed for use as a solstitial observatory. Because the terrain is quite different from Cuzco, it does not use the system of horizon-marking pillars described by Aveni[2] and Zuidema.[3] The flexibility of the Inca astronomers in adapting their observing techniques to the local environment suggests that they were interested in the astronomical event and not simply in making a ritual observation.

The results we wish to report on here involve the structures that Bingham called the "Torreon" and the "Intihuatana Stone."[4] We will present evidence that we believe demonstrates that the Torreon was useful for the observation of the June solstice, the solar zenith passage, and possibly constellations. The Intihuatana Stone itself does not seem to have been designed as an astronomical instrument (at least in any way we have fathomed), but its site may have been of great importance. Observations of sunsets made with reference to apparently artificial structures on the nearby ridge of San Miguel (located across the gorge of the Urumbamba) may have been used in calendric observations.

THE TORREON

A complete description of our findings on the Torreon has been submitted elsewhere (Dearborn and White, 1981), so the discussion here will be brief. The Torreon or "watch tower" is a temple structure that sits on a rock promontory with a clear view of the eastern horizon. Bingham noticed several similarities between the Temple of the Sun in Cuzco and the Torreon, including the fine masonry, the curved "semicircular" wall (FIGURE 1), and the existence of water flowing nearby.[4]

Two windows penetrate the curved wall; one faces northeast, the other southeast. The interior is dominated by a large carved rock (or "altar"), which extends from the northeast window westwards through the center of the temple. This altar is part of the rock that supports the Torreon itself. It has been cut flat on top, with the exception of a small raised section or low spire in the southwest quadrant. One edge of the raised section runs along the center of the altar and points out of the northeast window.

Theodolite measurements, accurate to 3 seconds of arc, were made to determine the orientation of this edge. It was found to lie within $2 \pm 5'$ of the direction of the rising point of the sun on the June solstice, which makes it a very precise sighting device for naked eye astronomy. The ter-

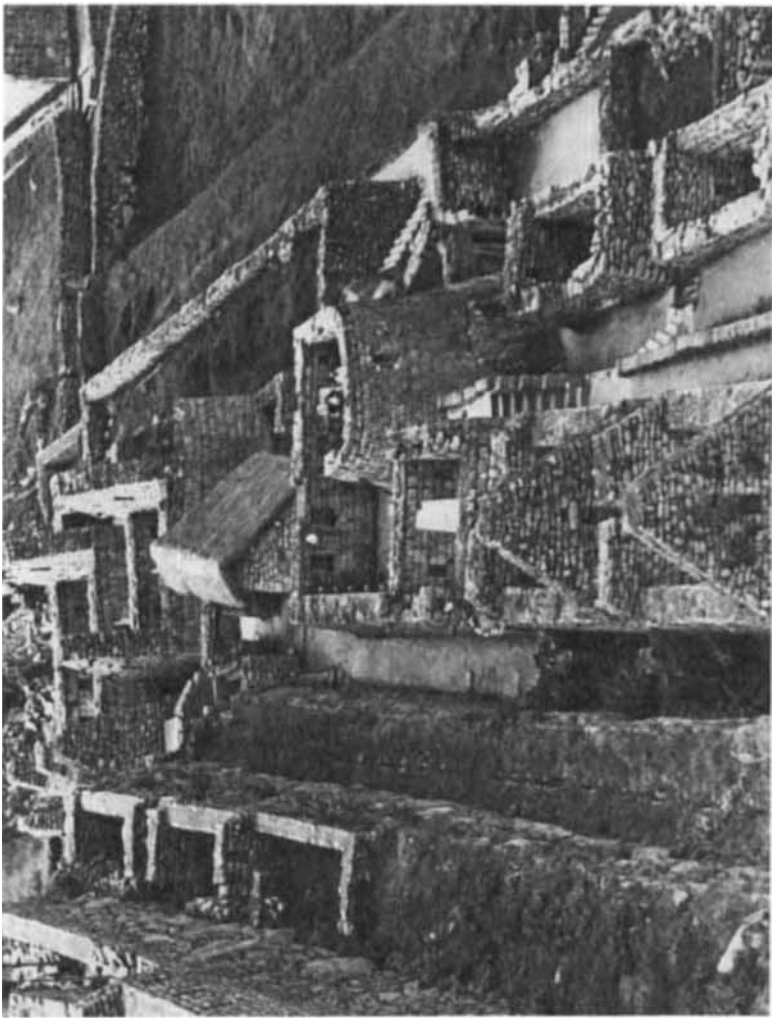

FIGURE 1. The curved wall of the Torreon sits on a rock projection over the Royal Mausoleum with a clear view of the eastern horizon. The southeast window and the serpents door are seen from this view.

rain at Machu Picchu is much more vertical than that in the Cuzco region. For the most part, the eastern horizon is more distant and less accessible. The technique of using pillars to mark the horizon would not be a suitable one over much of the horizon. A shadow-casting method using the solstice-pointing edge of the raised section of the altar would, however, be quite practicable.

Beginning in May, the sunrise illumination of the northeast window (or, more precisely, the shadow of a plumb-bob hung in the window) will lie across the altar and touch the solstice-pointing edge. Each day, as the sunrise point moves farther north, the angle between the window illumination (or plumb-bob shadow) and the solstice-pointing edge decreases until they become parallel on the day of the solstice.

Garcilaso de la Vega describes the preparations for the solstice festival, which involved a three-day fast.[1] This suggests that Inca astronomers did not simply observe the solstice, but made observations to predict it. Given a fiducial mark such as the solstice-pointing edge of the altar's truncated "spire", the date of the solstice can be predicted by measuring the angle between the plumb-bob shadow and the solstice-pointing edge. Such a measurement can be made accurately in a number of ways. For illustration, Dearborn and White (1981) describe a method they tried involving a cord stretched across the window. In any case, the orientation of the window and the carved "altar" stone form a usable system for making precise observations (and predictions) of the June solstice.

The other window faces the ridge of Machu Picchu to the southeast, near the place where the Inca Trail crosses that ridge. Its orientation is such that the sun, moon, and planets would never be observed to rise directly in the window: the window is oriented too far below the ecliptic. We, therefore considered the stars that would appear to rise in the strip of sky viewed from the window.

This strip of sky contains a large segment of the Milky Way, and includes several Inca constellations.[5] The constellation "Collca" (involving the tail of Scorpio) was found to lie just above the horizon at sunset on the day of the June solstice. Urton has described how modern Quechua-speaking groups observe the tail of Scorpio along with the Pleiades (also called "Collca") to signal the time of the solstice.[6] Since the Pleiades have approximately the same declination as the June solstice point, they are observed to rise through the window facing northeast. The event occurs just before sunrise as the solstice approaches. The two windows may then have been used together to observe a system of constellations.

Following the suggestion of J. Molloy, we examined the orientation of the two windows for another use. The widest possible observing angle through a window is obtained by viewing across the window jambs. The technique of using window jambs to define a position on the horizon and make astronomical observations has been used at Casa Grande[7] as well as Chichén Itzá.[8]

In the Torreon, we found that cross-jamb views made from the two windows overlap for only a 4° segment of the southeastern horizon, centered on the position of sunrise on the zenith passage date (February 14, October 29). During most of the year (February-October), the light at sunrise enters the Torreon through the northeast window. From October through February, however, it enters through the southeast window. Only for a five- or six-day period on either side of the zenith passage date will light enter both windows at sunrise.

As described here, the windows of the Torreon do not form an instrument for observng the precise date of zenith passage; they could be used together as a precise observing instrument, however, by observing the portions of the interior illuminated at sunrise. The Torreon, then, may have been used to define the period of time in which zenith passage occurs, and the precise date of zenith passage may have been observationally determined elsewhere.

In summary, the Torreon is designed for use as a precise instrument for observing the June solstice. In addition to this, it could be used to observe constellations and the approach of the zenith passage date.

THE INTIHUATANA STONE

The so-called "Intihuatana Stone" is one of the highest points of the citadel; it sits atop a terraced pyramid on the western edge of the plaza. Its altitude would allow observations of both the eastern and western horizons, but a wall constructed on the top of the pyramid restricts the view of the eastern horizon as seen from the Intihuatana Stone. With the exception of the ridge of San Miguel to the northwest, the western horizon is at a great distance and is unsuitable for constructing pillars to mark sunset positions.

The stone itself (FIGURES 2 and 3) is intricately shaped. The base is not quite rectangular, with approximate dimensions of 2 × 1.6 meters. The top of the base descends in a slow helix around a central tapering spire or pylon. The pylon is truncated at a height greater than 50 cm above the base; the top surface of the pylon is beveled at such an angle that it ap-

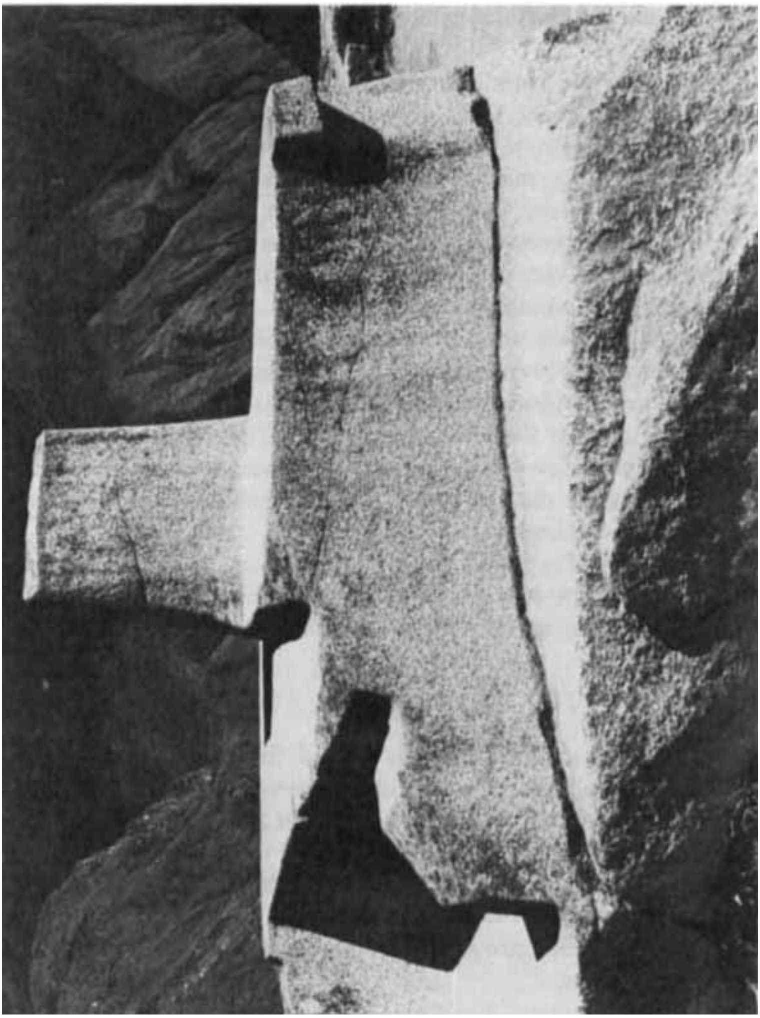

FIGURE 2. Looking southwest across the Intihuatana Stone, a short pylon or spire projects above the base.

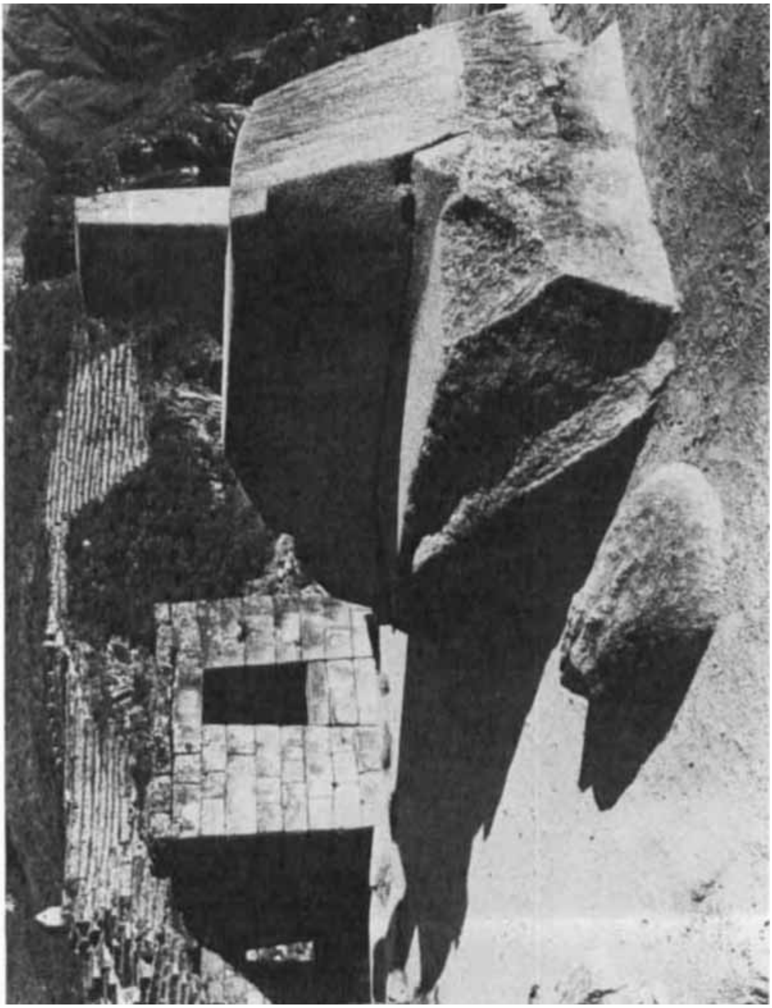

FIGURE 3. The Intihuatana Stone as viewed from the north.

FIGURE 4. A near-infrared telephoto view of the ridge of San Miguel as seen from Huana Picchu. To the left (south) the pillars (covered in foliage) rise above the jungle with two mounds or pyramids between. On the right, a rock outcropping is penetrated by a hole or window about 2 meters below its crest. As viewed from the Intihuatana Stone, the sun will shine through this window on May 11 and August 2.

pears to lie in a plane with the distant southwest horizon. While the faces of the pylon are not precisely flat, the azimuthal orientations are approximately 126° and 299° (narrow faces) and 40° and 225° (broad faces). The section of sky observed to set over the spire (when facing it square on) is centered on the declination strip $-45°$, which is 21½° south of the ecliptic plane; therefore, the sun, moon, and planets would never be observed to set within this portion of the sky. Perhaps coincidentally, however, it is the same strip of sky that would be viewed to rise through the southeast window of the Torreon.

While the stone itself does not seem to have any use as an observing instrument (at least, none that we have been able to determine), the site may have been important. Because of its position and altitude, an observer on the Intihuatana Stone pyramid has an unobstructed view of the ridge of San Miguel. This is one of the few segments of horizon near enough to the citadel to make the construction of pillars a suitable method for marking a horizon position.

While examining the ridge with a small telescope, Mr. Bernard Bell, one of the expedition members, observed what appeared to be two pillars that stuck up above the jungle and that appeared to be artificial. Slightly further north, he observed a natural rock outcrop that appeared to have a window through it (FIGURE 4). Near sunset, when there was great contrast between the sky and the ridge, the window was clearly seen through the "backlighting" condition.

Dr. Manuel Silva, an anthropologist from the Instituto de Cultura who was accompanying our expedition, told us that he believed the pillars (and two mounds between them) to be parts of an old Huaca. On questioning some local farmers, he reported that, while a trail up the flank of San Miguel used to exist, it had not been maintained or used in over ten years. Reaching the San Miguel ridge would, then, require one to climb more than 1100 meters at an inclination of 65° to 70° through chest-high brush or jungle containing large numbers of poisonous snakes (fer-de-lance). Not being prepared at that time for such a trek, we were unable to reach the ridge to examine these structures closely and to determine whether or not they were artificial. We did, however, calculate the date on which the sunset occurs behind each of the structures as viewed from the Intihuatana Stone.

The window (which we dubbed "Pilar" for ease of referral) is located about 2.3 km from the Intihuatana Stone, and the opening is approximately 30 × 18 cm. Observations of the window from different locations suggest that at least one side is two meters deep. The strip of sky

that passes beyond the window is at declination strip 17.7°. This gives two dates (May 11 and August 2) on which the sun sets behind the rock outcropping and shines through the window for a few extra seconds. Neither of these dates has any astronomical significance. The August date corresponds to the beginning of the period that is now called Herranza, which is associated with the time when the earth becomes fertile (the beginning of the planting season).[9]

There is also a possible association between Pilar and the observations in the Torreon. The dates on which the sun shines through Pilar closely bracket the dates on which the portion of the altar stone containing the solstice-pointing edge is illuminated at sunrise. Observations can be made to observe the solstice during this time.

Finally, Urton has pointed out to us that the time between solar passages behind Pilar closely corresponds to three sidereal lunar months, a period that Zuidema believes to have been an important unit of time in Inca calender.[3] While windows in rock are not common natural formations, they do exist; proof that Pilar is artificial must await closer examination of the crestline of the San Miguel mountain.

The "Huaca" pillars are located slightly over 2° and 3° north of Pilar. The northernmost pillar is thinner and, as viewed from the Intihuatana Stone, is covered with foliage. The dates when the sun would appear to set beyond the pillars are April 29 and May 3 in the late fall, and August 10 and 14 in the late winter. These dates correspond closely with the Festival of Santa Cruz (May 1–3),[9] and occur in a period associated with the harvest season. Again, proof that the pillars were used for the purpose of horizonal astronomy and to determine festival dates must await closer inspection.

Any expedition to San Miguel Mountain should examine the positions corresponding to sunset on other astronomically significant dates (solstice, nadir, passage). Since most of the ridge is covered in jungle impenetrable even to infrared film, a close inspection in person is mandatory.

CONCLUSION

The Torreon and the system including the Intihuatana Stone and the San Miguel Ridge are suitable for making astronomical calculations. The precision with which these Inca artifacts can be used strengthens our belief that they were so used.

In addition to the Torreon and Intihuatana Stone, a number of carved

stones in the citadel area were examined for orientations suitable for astronomical observations. In one instance a crude alignment was found, but nothing with the precision of the Torreon.

Perhaps the most interesting structure requiring additional work is the site Bingham called "the Temple of the Moon."[14] While it is located on the north flank of Huana Picchu, where the South Celestial Pole is not visible, it is oriented along the cardinal directions, with walls facing due north, east, and west. Part of the structure is a narrow hall or corridor with high walls, which is oriented due north-south. Such a design would be particularly useful in observing the daily change in the altitude of the sun as it transverses the meridian. In this way, solar zenith passage could be observed very accurately.

We believe that our expedition was successful in finding evidence concerning the types of observations that interested the Inca. It has, however, opened our eyes just enough to see that much more study is needed. Additional work must be done on the ridge of San Miguel, at the Temple of the Moon, as well as other places in the citadel.

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The Information System of Middle Horizon Quipus

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IF THE DEEPEST goal of explorers in the field of archaeoastronomy is the recovery of the patterns of ancient minds—knowledge of ancient ways of observing the ordering of the natural world, knowledge of the ways of structuring novel events within that systematic cosmology—then the study of Peruvian quipus is definitely worthy material for exploration. Quipus remain undeciphered as to content, but their structure, their grammar, and their mathematical syntax can be clearly appreciated. Since the appearance of evidence linking the Mesoamerican codices with astronomy, many efforts have been made to extract astronomical information from the Peruvian quipus. Although such information has not yet been obtained, the relationship remains a very probable one. Studying quipus and following the patterns of these ancient mental paths may, in some way, someday, lead us to direct knowledge of Peruvian astronomy, but more certain is the joy of pursuing the thought patterns that must have been part of, or at least coherent with, ancient cosmology and astronomy.

Quipu, which is the Quechua word for knot, is the term that the Incas used for their knotted string mnemonic devices. Several early references to Inca quipus suggest their broad use as data retrieval systems: for recording history, for census information, for treasury data,[1-3] and for law court records.[4] Also, 16th century drawings of quipus exist that, by visual association, at least, link astronomy and quipus (FIGURE 1). The sixteenth century drawings of quipus coincide almost exactly with the quipus found with burials in ancient Peru.[5] Knotted strings are still being used as mnemonic devices in Indian villages, usually for counting animals and crops, although one record indicates religious use.[6] Pre-Columbian quipus, however, remain undeciphered.

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FIGURE 1. And our Astrologer/Poet!
who knows of the rotation of the sun,
and of the eclipse of the moon,
of the stars and comets,
of the hours, the Sundays, the months, and years
and of the four winds of the world
and of the planting time for seeds for the food,
– since time immemorial.

English translation, William J Conklin

The drawing and the text are by Waman Puma[2] and date from about 1600. The astrologer/poet who is illustrated carries a quipu in his left hand, though it is not mentioned in the associated caption. In the distance the sun and the moon appear over the horizon. Markers or cairns appear over the horizon. Markers or cairns appear on the mountain tops, suggesting horizon astronomy.

The single most important breakthrough in understanding quipus remains that of Leland Locke,[7] who, in 1912, demonstrated that the quipus he studied were evidently not language, but rather purely numerical in nature. He also discovered that they used a decimal counting system of a positional nature, and that the concept of zero was present. Since then, using Locke's discovery, several notable efforts at linking the numbers that can be retrieved from the knots to calendrical and astronomical numbers have been made, especially by Nordenskiold[8] in 1925 and Day[9] in 1967. Such efforts have not, however, proved convincing to succeeding researchers, since the "proofs" characteristically involved a careful sifting and arranging of both astronomical and quipu numbers until coincidences were formed, with the remaining bulk of numbers unexplained.

Recently, the Aschers have recorded the numbers apparent in hundreds of quipus from all around the world.[10] All the quipus recorded to date (and the Ascher's records include some 400) appear to be from Peru's Late Horizon (that is, after about A.D. 1400), as are those recorded in the sixteenth century drawings.

Quipus, in their stored or closed condition, formed tight conical spirals (FIGURE 2), but were opened for information retrieval. The chroniclers suggest that the readers of the quipus were undoubtedly also their creators and caretakers. The process of constructing a quipu involves the technology of weaving, which, until the Conquest, was the most advanced technology in pre-Columbian Peru. Quipu construction involves selecting fiber materials, spinning the yarn, dyeing the yarn or the fibers, and then plying the spun yarns to create cords, and finally knotting in the information. Each quipu is a unique, constructed-from-scratch, complex textile. Spinning and plying rotational directions and knotting appear to be precisely controlled. The main cord may have been lashed to a bar, as is the heading cord in a Middle Horizon loom (FIGURE 3). Pendent cords are attached to the main cord.

The knots on the pendent cords are predominantly of two types: simple overhand knots and long knots (FIGURE 4). They are placed in position along the pendent cords, with the highest order of numbers closest to the main cord.[11] Thus, the number 4608 would be represented by four knots closest to the main cord, followed by six knots, followed by an empty space in the next position, and completed by a long knot with eight loops.

Pendent cords are generally arranged in groups, frequently in tens, as in the quipu in FIGURE 5. A group often has an attached or closely

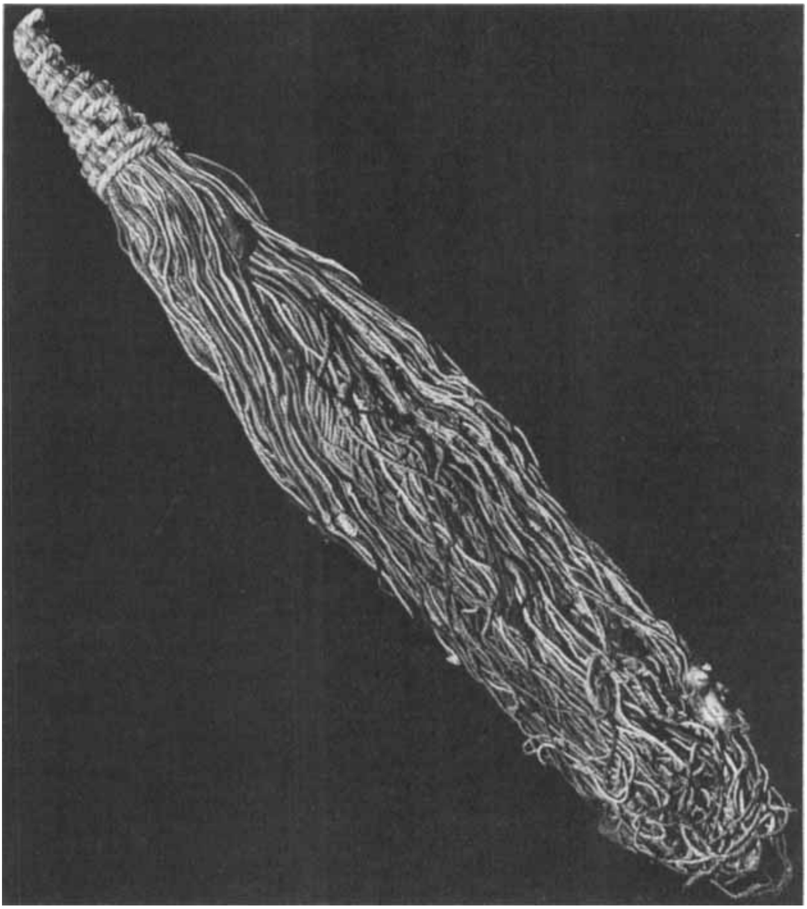


FIGURE 2. The quipu illustrated is a typical Inca quipu, shown in its rolled-up-for-storage condition. The spiral formed by the main cord forms a hand grip for manipulation of the quipu in its closed condition. The overall length is 61 cm. *S* plied cotton with occasional colored camelid hair.

associated special cord that extends in the opposite direction. The knots on this cord ususally prove to be the sum of all the knots in the group to which it is attached. This cord is referred to as the summary cord. Both pendent cords and summary cords may have supplementary strings with or without knots attached to them. Color coding also occurs in the sixteenth century quipus, with the distinctions between natural cotton shades apparently being the most important, but also using occasional dyed threads.

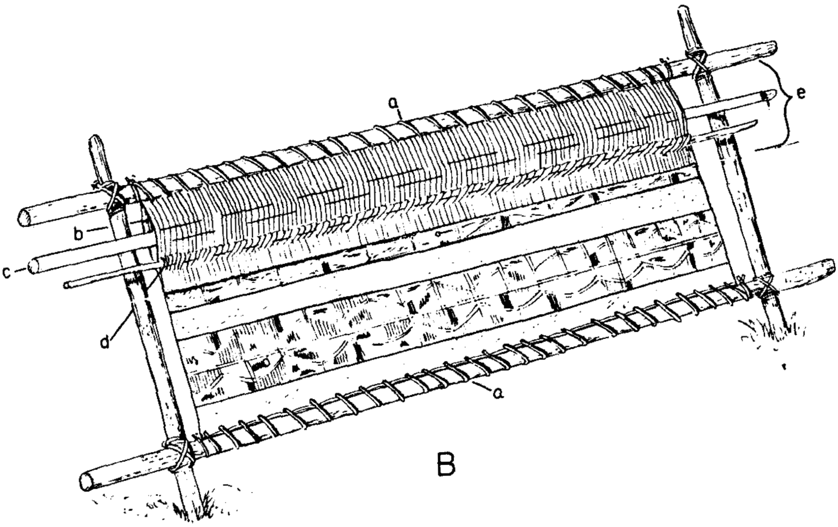


FIGURE 3. *The structural form of quipus suggests a relationship to the format of ancient* Peruvian looms, in that the main cord of the quipu is similar to a heading cord and the pendent strings are conceptually similar to the warp. In a quipu, the information is added on to the pendent cords: in weaving, the image pattern is added on to the warp. The proportions and format of quipus seem especially close to this reconstruction of a Middle Horizon horizontal loom. Quipus could have been constructed by having their main cord lashed periodically to a bar, as is the heading cord in its reconstruction. (From Bird and Skinner,[14] by permission of the authors.)

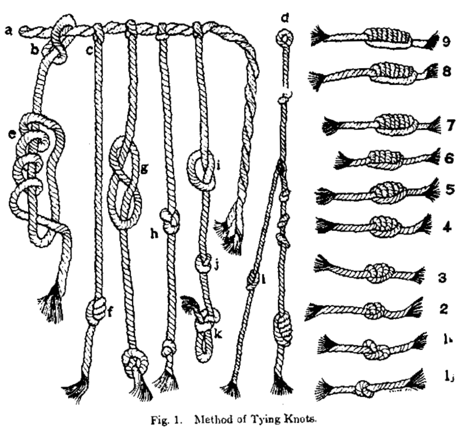


FIGURE 4. This illustration from Locke's publication on quipus illustrates the whole range of knots he found in the 40 quipus he analyzed. "J" and "2 through 9" illustrate the simple overhand and long knots most commonly found. (From Locke,[15] by permission of the American Museum of Natural History.)

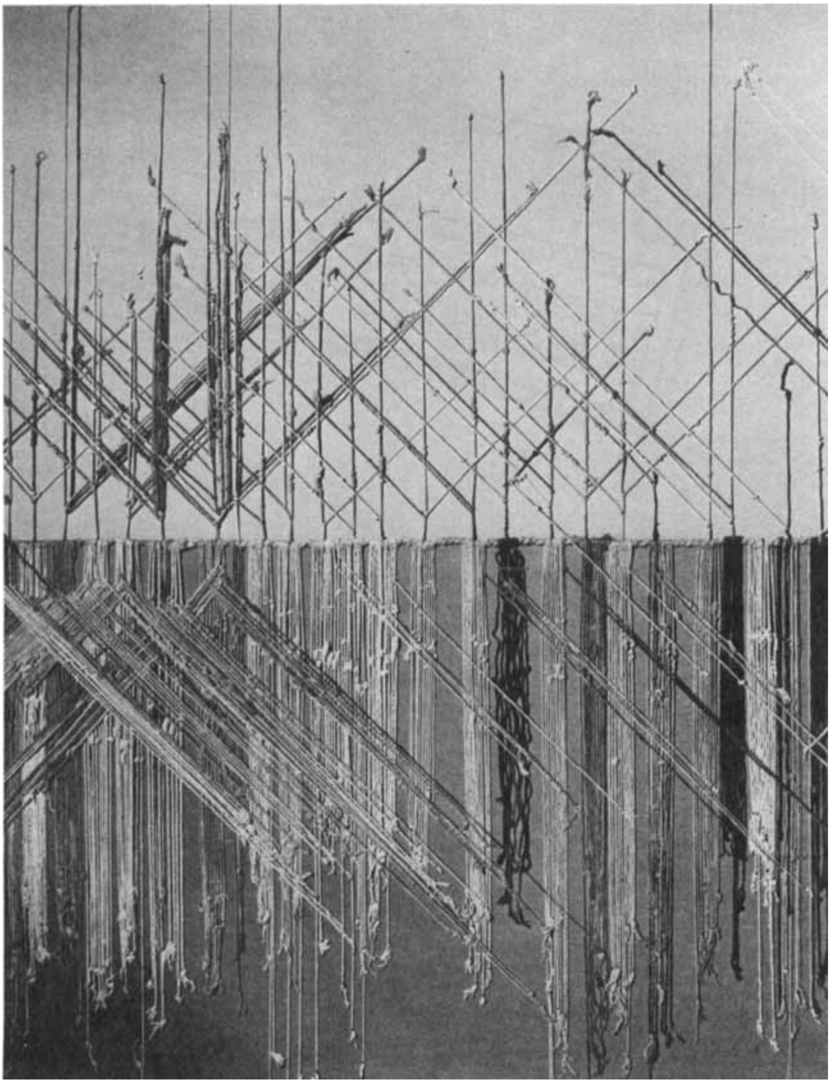


FIGURE 5. This Inca quipu has been mounted with the pendent cords extended down from the primary cord and the summary cords extended up. Subsidiary cords are mounted diagonally, to the left or right, in accordance with the two possible faces of their cow hitch attachments. The distance from the end of the longest summary cord to the end of the longest pendent cord is 100 cm. *S* plied cotton throughout, except for a few cords that are *Z* plied. (Private collection.)

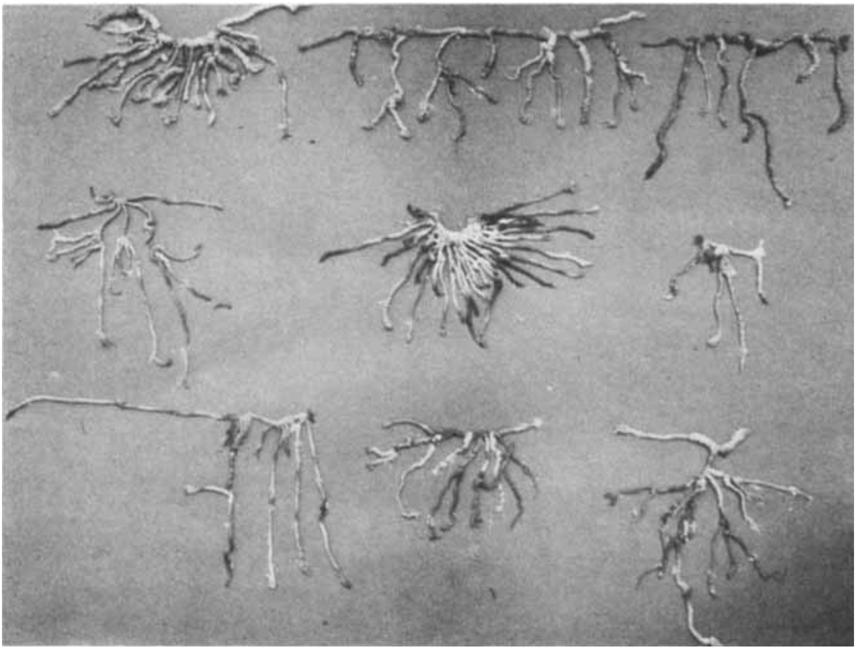


FIGURE 6. These deteriorated fragments of quipus are of critical importance. Though the complete numbers can no longer be read, the technical characteristics are clearly extant. The fragments can be dated by their associated material to Middle Horizon 2, or about A.D. 700. Z plied cotton. (Amano Museum, Lima, Peru. Photograph by J. Bird, by permission of the photographer.)

The quipus with which this paper is specifically concerned, however, differ considerably from these Inca quipus. They are visually and technically different and are herein called wrapped quipus, because one of their evident technological distinctions from the Inca quipus consists of colored thread wrapping on the pendent cords. They appear to be about 700 years older than the Inca quipus and their analysis provides a glimpse into the evolution of one aspect of pre-Columbian mathematical thought.

The dating of these wrapped quipus is dependent upon the reported association within a burial lot of fragments of wrapped quipus with Huari pottery and a Huari mummy (FIGURE 6). The discovery was made by Yoshitaro Amano in 1968 at a site called Pampa Blanca, which is near the Hacienda Huayuri in Pampa de Nasca. Amano's find was photo-

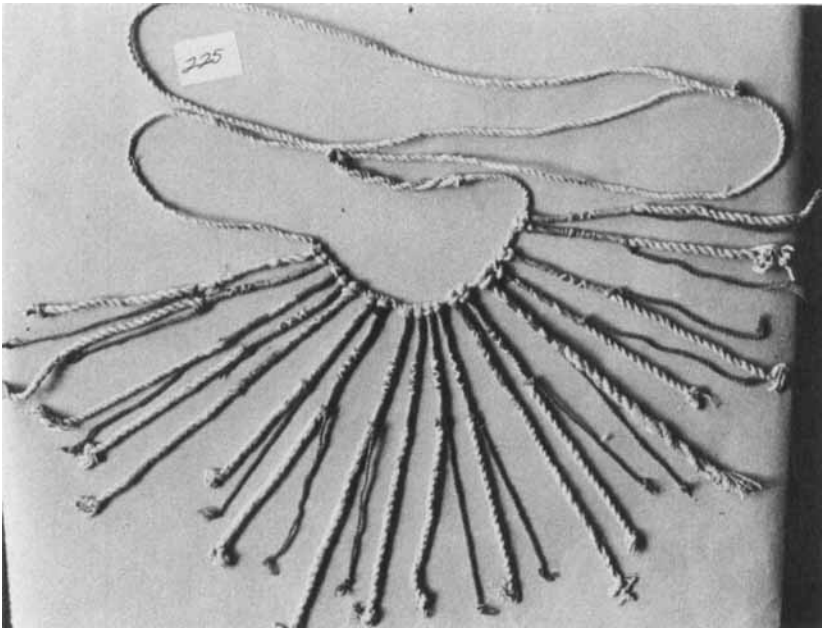


FIGURE 7. This small quipu appears to have all its information contained in its patterned wrapping and colored pendent cords. It has no information knots, but is technically far more coherent with the Middle Horizon quipu fragments than with Inca quipus. The length of the primary cord is 114 cm; that of the longest dependent cord is 15 cm. Z plied cotton. (American Museum of Natural History, T-225(1981), by permission.)

graphed by Dr. Junius Bird, and details were recorded in a letter from Dr. Amano to Dr. Bird in 1978. The burial lot record consists of three pots, the mummy, and the fragments of knotted strings. The pottery can be clearly dated to Middle Horizon 2 in the Berkeley series, suggesting a date of A.D. 700.[13] Although badly deteriorated, three important characteristics of the Pampa Blanca knotted strings can be determined. The shanks of the pendent cords are wrapped with patterned multicolored thread, there are no long knots present – only multiple overhand knots, and the plying of the cords is in the Z direction. The plying directions herein recorded are the last plying directions, since those are what would have been visible to the reader of the quipu.

The American Museum of Natural History has recently received several wrapped quipus without provenience, but with very similar technical characteristics (FIGURES 7 and 8). Like the Inca quipus, they roll

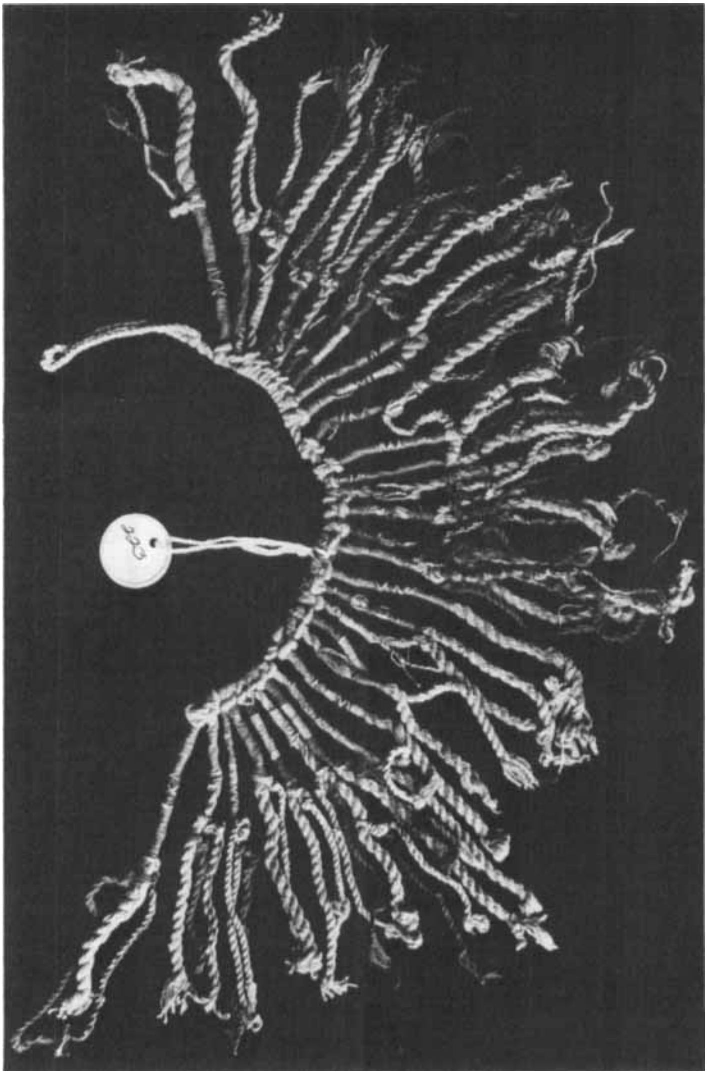


FIGURE 8. This small quipu also appears to have most of its information stored in the colored patterning, but it also has several types and colors of pendent cords and contains small numbers of simple overhand knots, but no long knots. It is thus consistent with the prototype Amano fragments. The length of the primary cord is 23 cm; that of the longest dependent cord is 14 cm. Z plied cotton except for red and purple details of camelid hair. (American Museum of Natural History, T-223 (1981), by permission.)

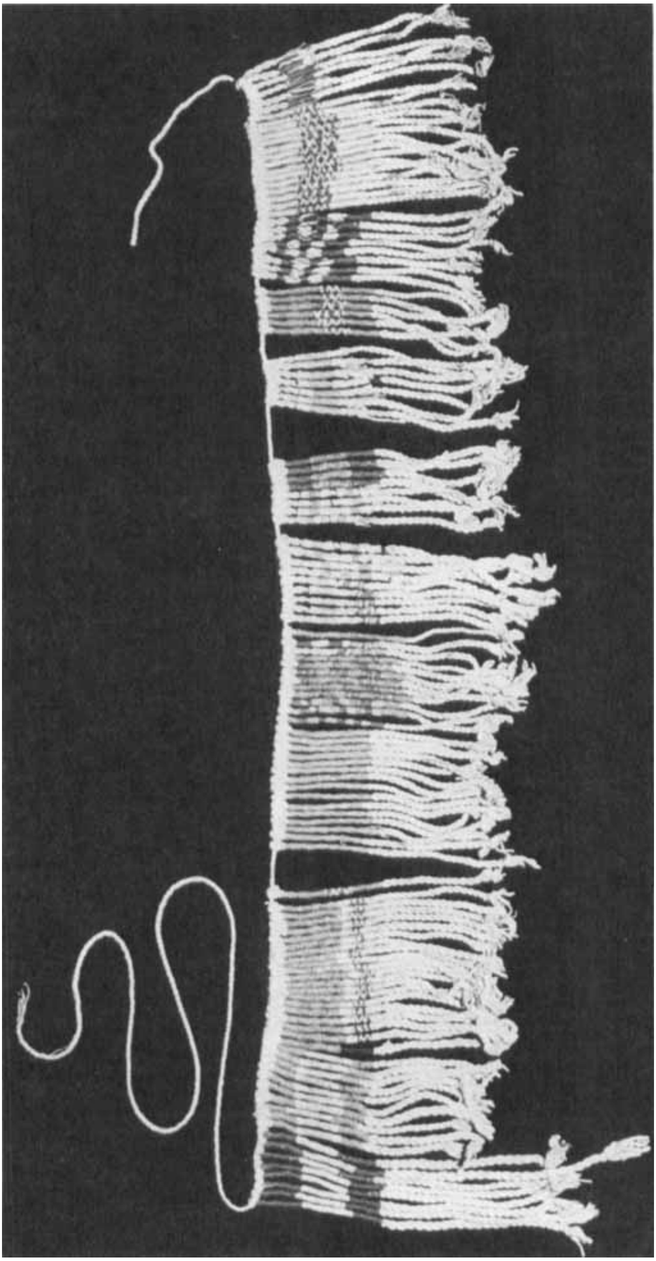


FIGURE 9. This beautifully constructed small quipu has elaborate pattern wrapping of the pendent cords. A few small dependent cords exist. Its technique is largely consistent with the Amano fragments. The main cord has one long end and one short end. The long end was used to complete the tying up of the stored quipu (FIGURE 10), and thus is probably the beginning of the recorded information, since it would have been the first portion seen when the quipu was opened from its stored condition. The length of the primary cord is 113 cm, that of the longest dependent cord is 18 cm. Z plied cotton. (American Museum of Natural History, T-222 (1981), by permission.)

up to form a spiral cone. The specimens are all small, like the Amano specimens. Each quipu, in its rolled condition, would fit easily into the palm of the hand, and could readily be carried about, like a book. Unrolled (FIGURES 9 and 10), they reveal groups of richly patterned pendent cords. The patterning seems to demark groups of cords. The information seems to reside almost exclusively in the color wrapping systems and cord colors. These quipus have very few knots and there are no long knots or summary cords.

Another example of a wrapped quipu is to be found in Locke's 1923 publication.[15] His quipu number 32 has red wrapping around the shanks of the pendent cords, contains only overhand knots, and is listed as coming from Pachacamac. It seems probable that this example is a Middle Horizon quipu.

The largest presently known wrapped quipu, unfortunately without provenience, also forms a spiral cone in its stored condition (FIGURE 11). It shows evidence of having been sealed in its stored form with a red paste, probably cinnabar – a remarkable parallel to the western tradition of red wax sealing of valuable documents. The complexity of its patterning is evident even in its compact state. This quipu has a primary cord some two meters long (FIGURE 12).

A set of technical terms will help in the description of its information system. Cords attached directly to the primary cord will be called secondary cords. Cords dependent upon secondary cords will be called third order cords, with fourth order cords, fifth order cords, etc. following successively.

Although recognizably similar to Inca quipus, this 101-cord wrapped quipu has important differences. The primary cord is constructed of five-strand plaiting and each secondary cord has been connected by inserting its looped end into the plaiting before forming the cow hitch. The cow hitch connection around the primary cord is simpler, but less secure. The secondary cords are coded by colored, and in one case patterned, wrapping. Two-color cords are formed by interlocking two plies of different colors, and then plying to form the barber pole effect. (Two-color cords occur on both Inca and wrapped quipus.) Variegated cords on the wrapped quipu have a very complex formulation, involving different spinning directions for different portions of the thread. Knots are characteristically simple knots, but there are no long knots in this large wrapped quipu.

There are 100 "normal" secondary cords attached to the primary cord. They are attached in groups of five, with twenty such groups. There are three small white secondary cords that have no knots. They may have

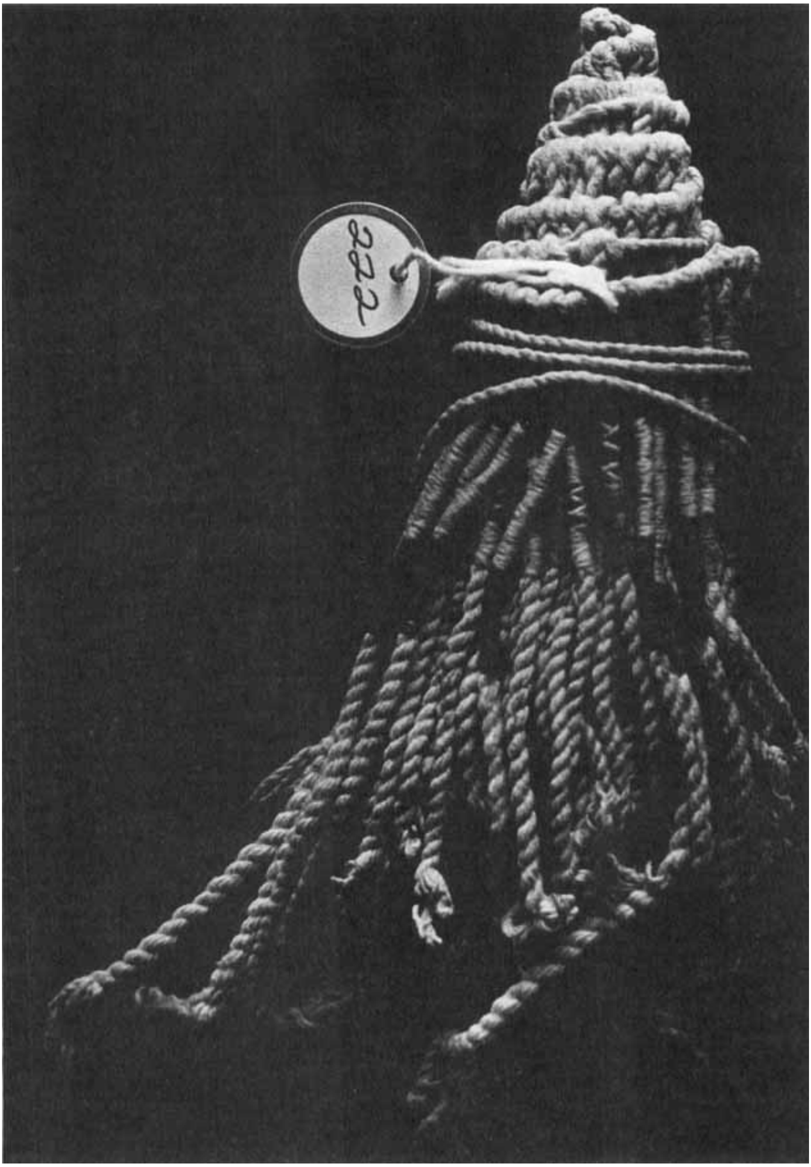


FIGURE 10. The quipu of FIGURE 9 in its stored condition.

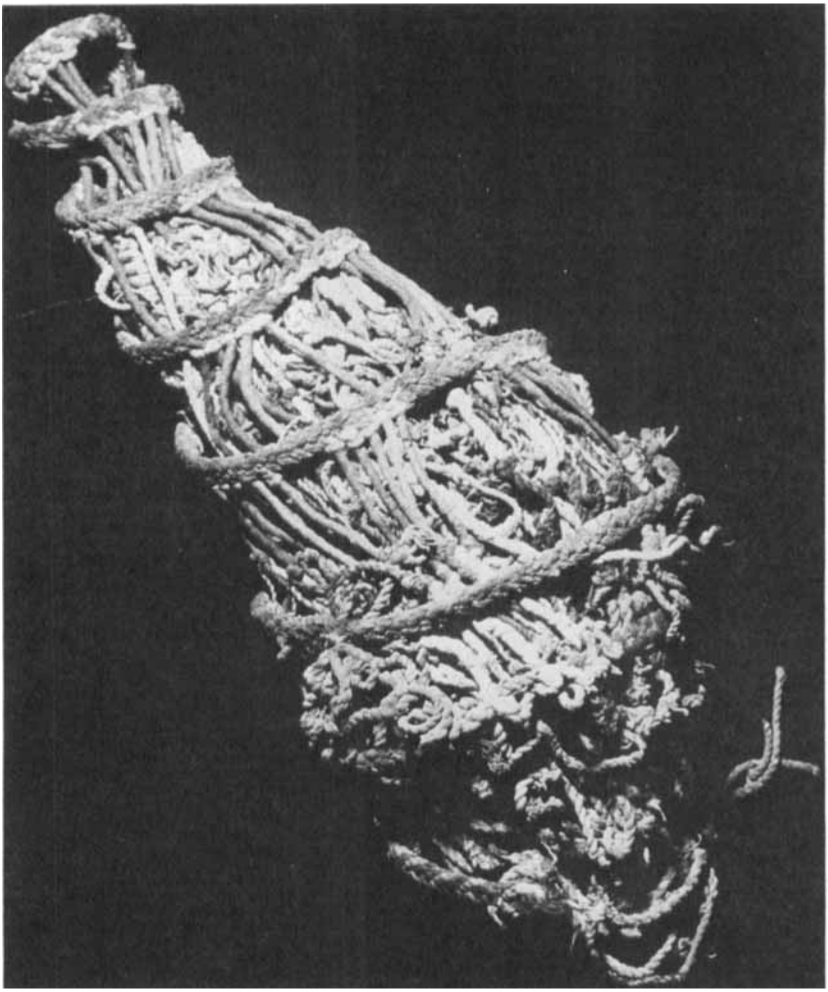
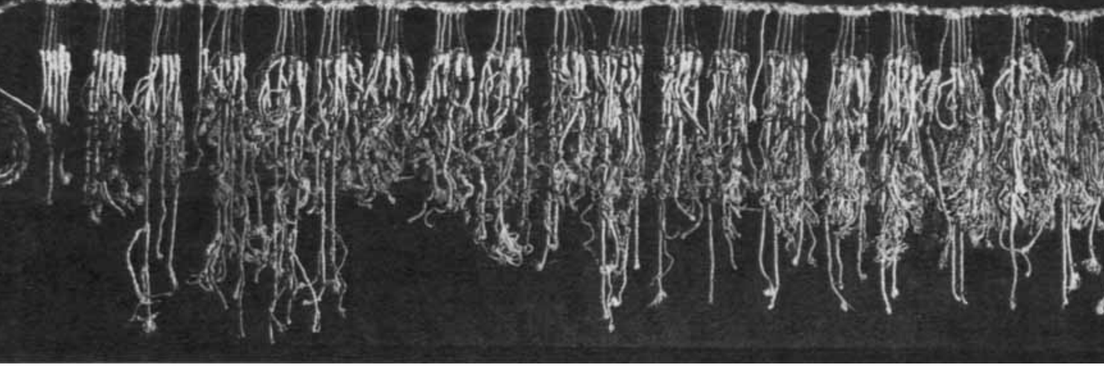


FIGURE 11. This large Middle Horizon quipu was apparently sealed in its rolled condition, presumably at the time of its burial, with a red paste, confirming the fact that such quipus were stored in a spiral form. The long end of the primary cord was wrapped around the spiral quipu. In its stored condition, its colored and patterned cords seem to be in total disarray. The length of the main cord is 190 cm; that of the longest secondary cord is 36 cm. Z plied cotton. (Private collection.)



2. When opened, this large Middle Horizon quipu displays a total of 100 consistent secondary cords, three short se
nay have been used to support the quipu, and one unique complex secondary cord. Most of the secondary cords have u
cords, and, in some cases, up to two additional orders of cords. The knotting consists mostly of simple overhand knots,
present. The construction is entirely of cotton, predominantly *S* spun. Many colors of dyed cotton are present. The righ
cord is broken off, but probably consisted of a loop that has been lost. *Z* plied (externally visible plying direction) c

been used as marker cords or, perhaps, they may have been used either to hold up the primary cord or as a lashing to the loom bar. There is one very special secondary cord. Every aspect—its construction, its wrapping, its knotting, its third order cord colors, etc.—is unique and is not found anywhere else in the quipu. Reading from left to right, it occurs at the beginning of the seventeenth five-cord grouping.

All the apparent information in the quipu is contained in the accompanying chart (FIGURES 13 and 14), which is drawn in such a way as to graphically represent the quipu. The recording method, using dot placement within a matrix, is an attempt to record the information contained in the quipu in a form that is not dependent upon Arabic numerals or languages. The chart should be read, as the quipu presumably was, from the top down. The information is recorded in the same vertical order as was found on the quipu.

The top portion of each secondary cord is wrapped with colored yarn—blue, tan, rust, brown, or green—with the colors occurring in the same sequence within each of the five cord groupings. Thus, the color and position information are redundant. The colors are actually complex and muted, but are represented in the chart by simple color names.

Ten types of third-order cords occur, each of which has its special color identity and each of which always occurs in the same position on the secondary cord. Again, color and position convey the same information and are thus redundant (FIGURE 15).

The first of the third-order cord types, reading from the top down, is a red (actually a rust) and white two-color barber pole patterned cord. The red and white cords occur immediately after the color wrapping on all of the normal secondary cords except for the first three groups of five cords (reading from left to right) and except for the special secondary cord noted above. The red and white third-order cords have either no knots, one knot, or two knots. The normal sequence, reading from left to right within a grouping of five secondary cords, has four cords with two knots, followed by one cord with no knots. This pattern occurs twelve out of seventeen times.

The second of the third-order cords is a solid red cord (again, actually more of a rust color) and these cords occur wherever the red and white cords occur. They have predominantly two to five knots. The first four cords of each group generally have an assigned number, especially the first and second cords, which always have two and three knots, respectively. The number of knots on the last cord of each group generally

varies from two to five. This information seems to imply a base five number system.

Following the position of the red third-order cords, each of the secondary dependent cords is itself knotted with from one to eight simple overhand knots. The pattern of these knots within a five-group reads, with variations, 1–2–5–7–3. The secondary cords in the first five-group have colored wrapping and are themselves knotted, but have no attached third-order cords. Since they occur at what is apparently the beginning of the quipu, the basic knotting of the cords and their wrapping, without elaborating attachments, could be compared to a musical pattern which begins with a basic drum beat before melodic elaboration occurs. The pattern of knots within the first five-group is 1–2–5–8–4. The repetitive nature of this pattern, which is repeated with miniscule variations on each of the secondary five-groups, suggests a kind of ritual repetition or incantation. Another interpretation the pattern suggests is that the quipu is but a fragment of a much larger catalogue or information system, or, perhaps, that it is but a fragment of a date sequence from a much larger calendrical system.

The white third-order cords generally occur on the first two secondary cords in each group, with the first having eight knots and the second having four knots. Occasionally there are additional white cords that do not fit this pattern.

The yellow third-order cords occur on 95 of the 100 cords, and also have highly patterned information. They have from zero to nine knots. Occasionally, a black thread attachment (or fourth-order cord), occurs. The yellow cords, more than any other of the information sets, seem to contain decimal information.

The red (rust) and blue third-order cords appear on 95 of the 100 cords; 90 of these have one knot, and five have no knots. This is clearly presence/absence or binary information.

The orange and blue cords are very similar to the red and blue set and also contain only binary information.

The orange third-order cords also contain only binary information and, in six instances, contain the same information as the orange and blue cords.

The black and white barber pole patterned cords usually have either one knot or no knots, although occasionally a small black tag cord has been added (fourth-order dependent cord) and, in eight instances, contain from two to eight knots. The black has disintegrated badly and, as a result, many of the black and white threads are missing. In five cases

where the black and white threads have no knots at all, a fourth order cord has been attached, as if to say that the information that was to be conveyed could not be conveyed by tying knots in the usual third-order fashion.

The brown and white variegated third-order cords also contain primarily binary information, but usually within each group of five there is one variegated cord that contains from two to eight knots, and, in three cases, these knotted cords themselves have fourth-order knotted cords with additional knots. The color variegation is formed by a complex pattern of *S* and *Z* spinning and plying. Reverse spinning often has magical implications in Peruvian village spinning today.

The final third-order series is dark green and white variegated. Its information pattern is similar to the brown and white variegated series—primarily binary information with a few cords containing additional knots. However, an exceptional condition occurs in the eighteenth five-cord group. On the first, fourth, and fifth of the secondary cords within the group, complex knotted string groups have been added. These are virtually little quipus in themselves, containing up to three more heirarchies of dependency with knot groupings containing up to eight knots. On the third of the secondary cords within the group, a tertiary cord of natural brown cotton containing six knots has been added.

In summary, no interpretation or translation of this large wrapped quipu is offered—only the data and its description. Comments on the patterning of the information have been offered in the hope that comparisons can be made with the characteristic patterns of information occurring in the kinds of data with which quipus were concerned, especially astronomy. For those who do choose to review the data, certain comments may be in order. The patterns on the chart indicate that when an uncharacteristic pattern occurs in the yellow cords, unusual patterns also occur in the final three cord sets. Also, since the yellow cords are the only ones that clearly use the decimal system, their role may be important. It should also be noted that the color sequence of the secondary cord wrapping has a broad similarity to the color sequence of the third-order cords. The color wrapping on the secondary cords, as well as their own knots, occurred before any of the third-order cords were attached, thus seeming to make that information more fundamental.

It seems apparent that this quipu demonstrates a very complex information format that uses binary and base five as well as base ten information sets. Base five systems occur most frequently, binary systems next most frequently. The textile coloring in virtually all cases merely

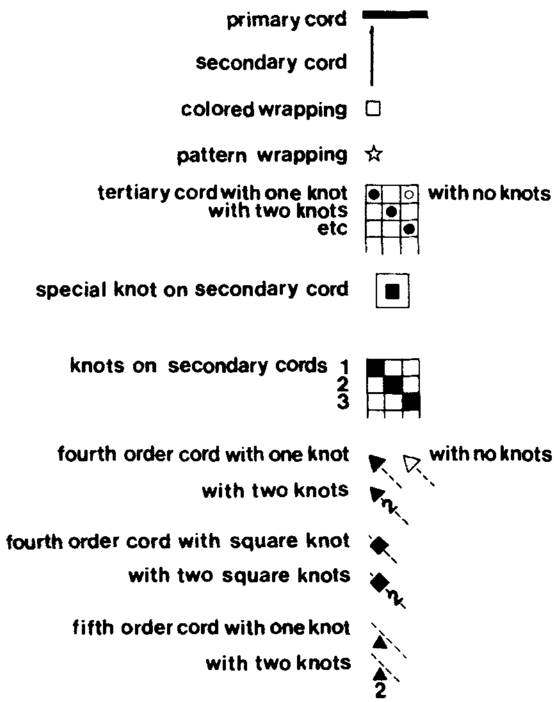


FIGURE 13. Large wrapped quipu data chart legend.

reiterates the positional information; it does not reiterate the numerical information.

A review of the developmental history of the textile techniques involved in quipus may offer some clue as to the nature of the subject matter of this and other Middle Horizon quipus.

Colored wrapping of warps is a patterning technique that was invented during the Early Horizon period and is distinctly associated with Chavin art and religion and dates from something like 1000 B.C.[12] Warp wrapping was the technology the Chavin artist/religionists invented to enable them to permanently imprint their religious messages onto the textiles that were distributed to the regions of their influence. Painted images were also distributed, but the warp-wrapped images were restricted to those of the most important dieties. These dieties show coherence with the dieties represented during the Middle Horizon period; hence, it is quite possible that the ancient Chavin tradition of conveying messages by pattern wrapping the warps with color is continuous with this Middle Horizon method of wrapping quipu cords to convey information.

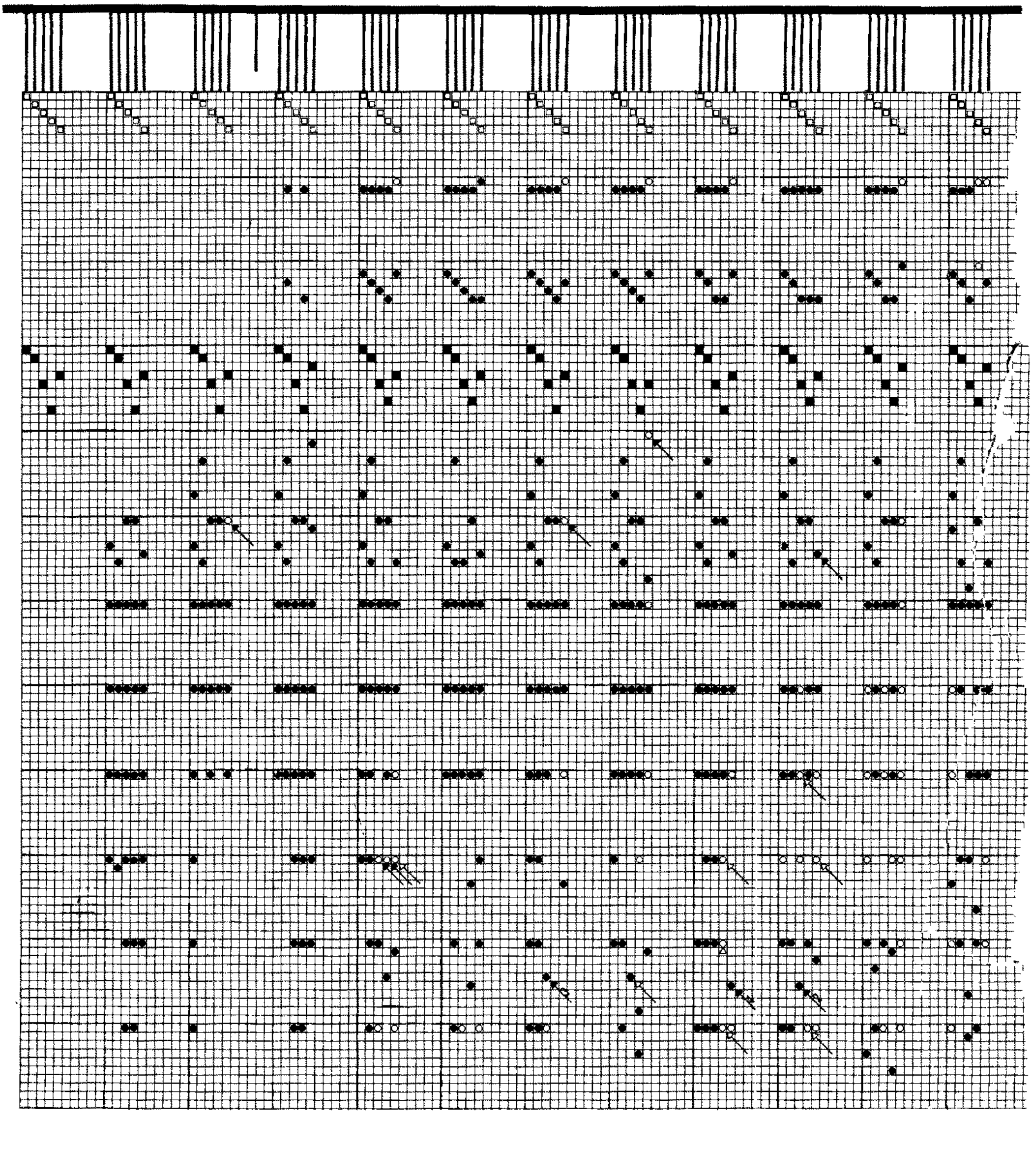
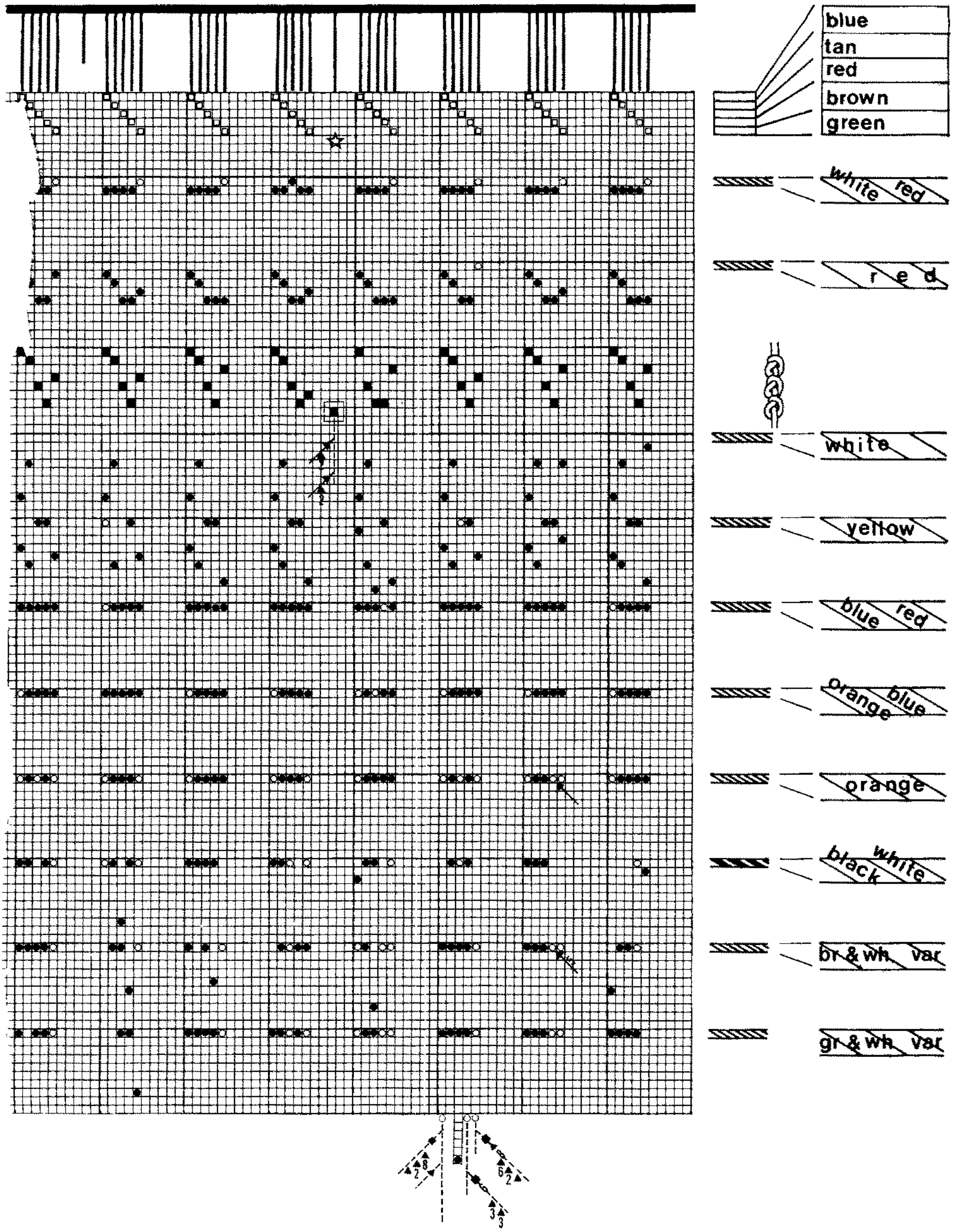


FIGURE 14. This chart is a graphic representation of the information contained in the large Middle Horiz



:on quipu. The format of the chart follows that of the quipu itself. For the legend, see FIGURE 13.

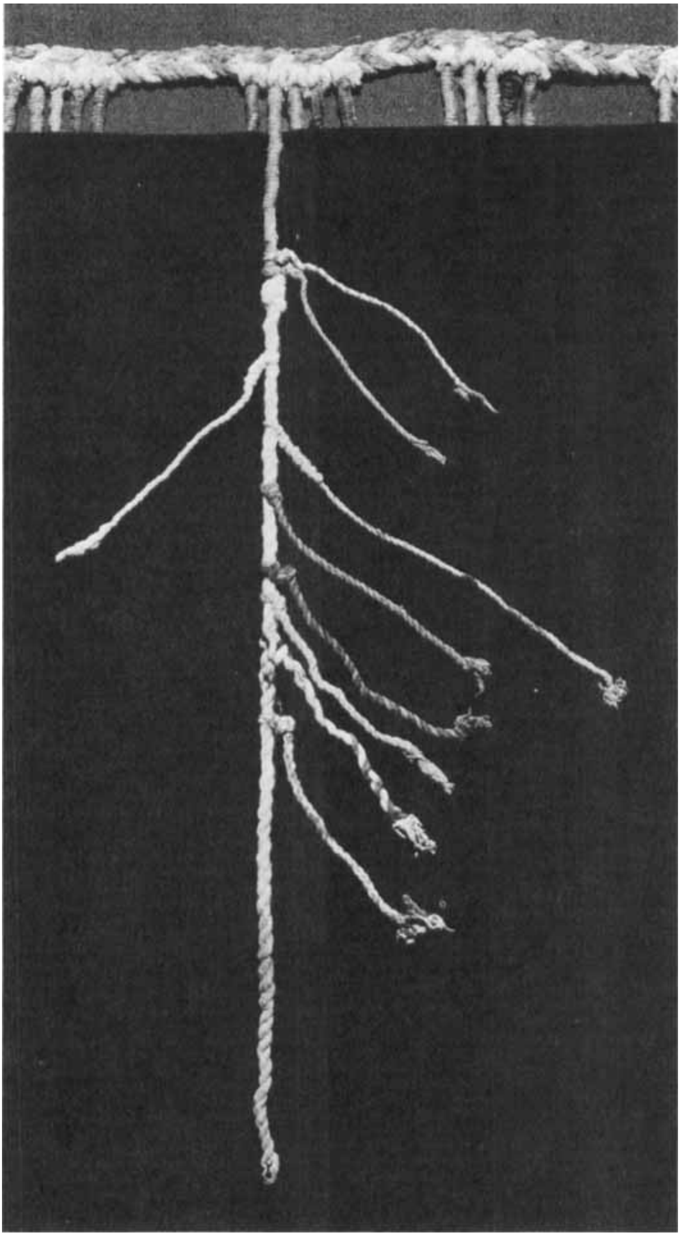


FIGURE 15. A single secondary cord of the large Middle Horizon quipu, showing each of the third-order cords and their information as recorded in FIGURE 13. The cord illustrated is number 72. Note that the brown and white variegated cord is missing in this case. Close examination indicates that it once was there, but has now disintegrated. Missing cords seem to occur only where black or brown dyes were used.

The evidence from these wrapped quipus, when reviewed, clearly suggests that quipus must have had a long period of development in Peru, and were not an Inca invention. The Inca quipu, with its characteristic decimal basis, its positional system, its shorthand long knots and summary cords, was the final pre-Conquest evolutionary form of a textile message-conveying tradition. The Inca quipu form must have gradually replaced the more complex, colorful, but redundant and repetitive quipus of the Middle Horizon period. The mathematics of the record-keeping Incas seems thus to have evolved from the art and ritual of earlier times. The decimal system seems to have nudged out a plurality of bases. Perhaps the astronomical information in Middle Horizon quipus will prove to be more concerned with ritual than with astronomical data as such.

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Ethnoastronomy of the Eastern Bororo Indians of Mato Grosso, Brazil

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INTRODUCTION

THE BORORO INDIANS were once one of the largest and most powerful of Brazil's indigenous interior peoples, occupying parts of what are now the states of Goias, Mato Grosso, and Mato Grosso do Sul, and eastern Bolivia (14–19° S latitude, 51–59° W longitude), more or less the geographical center of South America. Linguistically, the Bororo are classified in the Macro-Gê superfamily; internally, they are divided into western and eastern groups. After fairly long contact with Europeans in their area, the debilitating effects of warfare and disease, coupled with diminishing territory exploitable for subsistence purposes, served to greatly reduce their numbers. Although, in the epoch of the Rondon Telegraph Commission (the first quarter of this century), a single Bororo village may have housed up to two thousand individuals, the Salesian missionaries, in 1962, totaled the Eastern Bororo population in the area at one thousand, while a population survey in 1964 listed only six villages with a total of 422 inhabitants.[1] Today, five Eastern Bororo villages are located along the networks of the Rio Vermelho and the São Lourenço and Araguaia rivers of south central Mato Grosso state, with a population estimated at some five hundred. No groups culturally identifiable as Western Bororo are known to exist.

Geographically, the Bororo region is characterized by tropical savannah, with some elevated plateau areas, lowland swamp and tropical forest, and lush rivers coursing throughout. The climate alternates between a rainy season from October to April and a dry season the rest of

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the year; temperatures are normally hot in the daytime, but may go below freezing at night during parts of the dry season. Obviously, intimate knowledge of these features allowed the Bororo indians to make the best use of the numerous food resources that served to support their large communities.

Bororo villages are located close to rivers, ensuring a relatively stable supply of food. The typical village (FIGURE 1) is round, with an average diameter of 100 meters, and has several noticeable features: a centrally located men's house and a ceremonial plaza that serves secular and ritual functions reserved for males, surrounding family dwellings of primarily secular importance – an important female area, and paths connecting the men's house to the perimeter dwellings and these later to the surrounding terrain.[2] These paths have restricted access and may pertain to some scheme of directionality. Allowing for local considerations of the slope of the land and the direction of the river (most rivers in the Bororo area flow from west to east), all villages have a consistent internal ordering and cardinal orientation. The cardinal orientation is established through

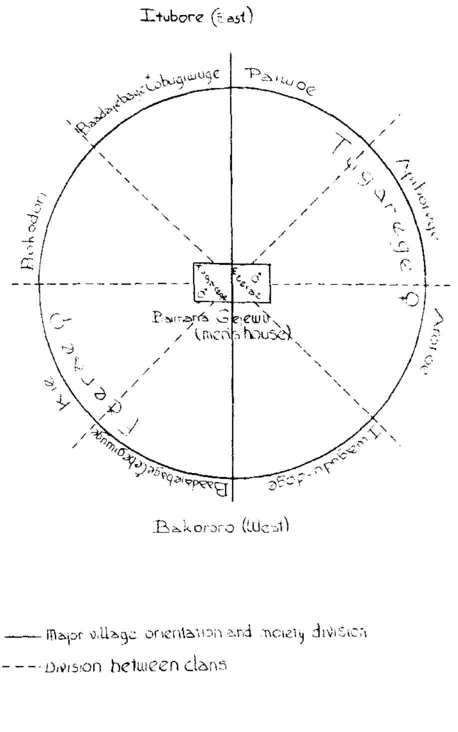

FIGURE 1. A schematic Bororo village plan. (Based upon Viertler,[2] EB1, and EB3).

two axes, an east-west division of the *Ečerae* and *Tugarege* moieties, and a secondary north-south axis defined by the placement and orientation of the *bai mana gejewu,* the men's house. Along the village perimeter each of the eight major clans have a specific location, which is further ordered along subclan divisions. This village plan is adhered to as strictly as local conditions permit, even when temporary shelters are erected during the hunting and gathering treks and when all the clans are not represented. It is through their village ordering that the Bororo orient themselves in both natural and cultural time and space.

BORORO ASTRONOMY

The Bororo conceive of themselves as an especially integral part of their environment; their name for themselves, *Boe,* besides distinguishing them from other racial and indigenous groups, is also glossed by the Salesians to mean "thing," "astronomical time," and "atmospheric state or condition." We would expect then, even if Lévi-Strauss, during his short field stay with the Bororo, had not found them stretched out upon mats at night looking up at the stars,[3] to find that they have a considerable knowledge of the celestial sphere. The power of observation that is so important to a lowland hunter and warrior was especially marked among the Bororo, who are reliabily reported to have been able to see the planet Venus in the full light of day.[4] This strength of vision and observation, naturally applied in their daily and seasonal activities, was just as naturally applied to the configurations and movements of the celestial sphere. A survey of the literature on the Bororo, especially the extensive data gathered by the Salesians,[5] has produced a large data base of star and constellation names and other celestial information, even from investigators who were not primarily interested or educated in this topic.

There appears to be no distinction in the Bororo language between star and planet, the same word, *ikuieje,* standing generically for both. "Constellation" likewise does not seem to have a separate gloss. The various data on Bororo stars and constellations are listed in TABLE 1. The listing is alphabetized according to Bororo terms; there are 32 distinct entries, several with variations. Wherever it was recorded in the literature, the identification with Western constellations and stars is given, but, in several cases, such identifications were not made and, since there is little augmentative information, there is, at the present time, almost no chance to determine recognizable counterparts in our own system of astronomy.

TABLE 1

BORORO STARS, PLANETS, AND CONSTELLATIONS

Name	Identification	Remarks	Source*
1. *Aiepa*	β Centaurus		RF
2. *Akiri-doge*	"White down": the Pleiades	Has special dry season import	EB1
2b. *Akiridogue*	"White down": the Pleiades		CA
2c. *Aquiridogue*	"Down": the Pleiades		RF
3. *Ari Reaiwu*	"Star that accompanies the moon": Venus, Jupiter, or other planet	Any star or planet that appears to accompany the moon; with recognized seasonal variation	EB1
4. *Bace Iwara Arege*	Orion's Belt	Stars in a straight line; *bace* is also the word for "heron"	EB1
4b. *Baxe Iwararegue*	"White rod": Orion's Belt	Described as young herons in the myth of the naming of stars	CA
4c. *Maxeuarareugue*	Orion's Belt	*Maxe*: "mosquito" *Maxe-agareuo*: "heron"	RF
5. *Ba Paru Kadoda Jebage*	"Those which cut the West of the village": some stars in Ursa Major	(The etymology of the phrase is not clear)	EB1
6. *Barogwa Tabowu*	"The star that appears at the break of day"	Term for whatever star or planet shines on the horizon at daybreak	EB1
7. *Bika Joku*	"Red like the eye of the anubranco (*Guira guira*)": Mars	*Bika*: onomotopeic word for the sound of this bird; its two calls are used as omens for the hunt	EB1
8. *Boeiga Biagureu*	"The little rifle (bow)"	Although glossed as "rifle" by the Salesians in this context, they also gloss *boeiga* as "bow"	EB1
9. *Boeiga Kurireu*	"The great rifle (bow)"	Diagramed in the vicinity of Centaurus	EB1

9b. *Boiga*	"Rifle, bow": star in the constellation of Canis Minor		RF
10. *Bokodori Jari Paru Kado Jebage*	"Holes made around the burrow of a giant armadillo (*Priodontes giganteus*) to catch it"	Four great stars resembling the pattern of these holes; no location given	EB1
10b. *Bocodori Jari Paro Cado Xobagui*	The constellation Centaurus		RF
11. *Caibore*	Star of the constellation of Canis Major	*Caibore* glossed as "mortar"	RF
12. *Ikoro*	Another term for a star or planet shining on the horizon at dawn	Used especially in songs	EB1
13. *Ikuieje-doge Erugudu*	"Ash of the stars": Milky Way		EB1
13b. *Kuiegge dogue Eruguddo*	"Ash of the stars": Milky Way		CA
14. *Ikuieje Kurireu*	"Great star": Venus		EB1
14b. *Cuieje Curireu*	Venus		RF
15. *Jekurireu*	"Great face": Venus		EB1
16. *Jerigigi*	"Freshwater tortoise": five stars	The head of this constellation may be Rigel of Orion	EB1
16b. *Geriguigui*	"Terrestrial turtle": Corvus	(Cf. with above, *Jerigigi*)	CA
17. *Kaia*	"Pestle": black spot in the Milky Way resembling a Bororo pestle	(No location given)	EB1
18. *Kaibore*	"Mortar": black spot resembling a mortar	(Cf. 11, above)	EB1
19. *Kudoro*	"Ararauna" (*Psittace hyacinthina*): constellation in the shape of this bird	(Blue Arara/Macaw: *Ano dorhynchus hyacinthinus*)	EB1
19b. *Kuddoro*	"Blue Macaw": a part of the constellation Pavo		CA
19c. *Cudoro*	Algol (β Perseus)	*Cudo*: "coldness, thick fog, haze" *Cudo Buto*: "winter, beginning of winter, of cold"	RF

TABLE 1 (*Continued*)

BORORO STARS, PLANETS, AND CONSTELLATIONS

Name	Identification	Remarks	Source*
20. Kunorireu	"Papagaio-Camperiro" (*Amazona ochrocephala*): stars in the shape of this large parrot		EB1
21. *Marido*	Sirius	*Marido*: buriti palm (*mauritia* sp.), also a rolled bundle of palm material carried in certain rites	RF
22. *Marido Aredu*	"Little ring": Corona Australis	(Cf. 21 above)	EB1
23. *Marido Imedu*	"Great ring": Corona Borealis		EB1
24. *Okoge Joku*	"Eye of the Dourado fish (*Salminus* sp.)": Aldebaran		EB1
24b. *Cogue Joku*	Aldebaran	*Cogue*: "salmon," "husband"	RF
25. *Pari*	"Emu" (*Rhea americana*)	Several black areas in the Milky Way, resembling a running emu; the head is located near the Southern Cross	EB1
26. Pari Bopona	"Thigh of the emu": α and β Centaurus	(Cf. 25 above)	EB1
27. *Pari Burea*	"Foot/footstep of the emu": Southern Cross	(Cf. 25 above)	EB1
27b. *Pari Burea*	"Foot of the emu": Southern Cross		CA
27c. *Pari Buriadogue*	The Southern Cross		RF
28. *Pobogo Aredu*	"Little Guacete (*Mayama americana*)" (i.e., the female of the species)	(After the great inundation, a female guacete (deer) and a male Bororo procreate the Bororo people)	EB1

29.	*Pobogo Imedu*	"Large Guacete" (the male of the species)		EB1
30.	*Tuwagou*	Unidentified		EB1
31.	*Upe*	"Water turtle": including stars of Scorpio		EB1
31b.	*Upe*	"Tortoise": four small stars and Antares of Scorpio	(The right rear foot may be Antares)	CA
31c.	*Upe*	"Turtle": Rigel	(Cf. 16 above)	RF
32.	*Uwai*	"Cayman" (*Caiman* gen.): in the proximity of Orion		EB1
32b.	*Uai*	"Cayman": Canopus		RF
32c.	*Wai*	"Cayman": constellation of the Argonauts		CA

* CA: Colbacchini and Albisetti[5] and RF: Rondon and De Faria.[6]

The "Remarks" column generally records descriptive information taken from the sources; occasionally this author's comments have been added in parentheses.[6] The list as a whole presents a fairly coherent set of data and can be found to correspond in general to other known systems of South American tropical astronomies.

With respect to individual stars, two categories of naming can be distinguished: the specific appelation of the star or planet, e.g., *Bika Joku*, "Mars," and a positional reference, e.g., *Barogwa tabowu*, "the star that appears at the break of day." This is a somewhat sophisticated system of marking positionality, and can probably be inferred to be in use with the constellations as well. In that the Bororo also possess a term for "zenith" (*Baru aiadada*, "center of the sky"), we can assume that certain key positions for stars and constellations, such as their nightly and heliacal rise and set and zenith passage (or upper culmination) were used to mark off periods of time during the night, and probably also the year. This would correspond in general to the timekeeping practices of the Bororo, which basically involve the description of the sun or moon's position (elevation in the sky before and after culmination) and also the latter's phases. When there is no moon in the night sky, certain stars or constellations are used in a similar way.[7]

Some discrepancies in identification in TABLE 1 will have to be left unresolved at the present time. Although, in general, the greatest credence is given to the data from the *Enciclopédia Bororo*, which represents the most complete work on the subject, Padre Venturelli cautions against the uncritical acceptance of all identifications, since none of the Salesian staff were intimately familiar with the topic even in Western terms (personal communication). However, even constellations such as the "Big" and "Little Rifle" need not be considered somehow intrusive or nonindigenous in the scheme. *Boeiga*, the term glossed in this context as "rifle," also refers to the Bororo bow; it apparently became extended later to include rifle, as a projectile-hurling weapon. It is not clear from the text why the Salesians preferred the later definition of the term to its more aboriginal use in referring to the constellation.

It is noteworthy that two different types of constellations can be distinguished: the star-to-star type, and the "stains" or black spots of interstellar dust in the Milky Way. The former are generally characterized by four or five stars arranged closely together; the latter may be individual spots (e.g., the Bororo constellation identical to the western Coalsack) or larger conglomerations. This second type is probably represented by the constellation *Pari*, a running "ema" or emu (*Rhea*

TABLE 2

BORORO MYTH OF THE NAMING OF THE STARS AND CONSTELLATIONS

Version A	Version B
1. *Bika Joku* (Mars)	1. *Jekurireu* (Venus)
2. *Akiri Dogue* (Pleiades)	2. *Akiri-doge* (Pleiades)
3. *Baxe Iwararegue* (Orion's Belt)	3. *Bace Iwara Arege* (Orion's Belt)
4. *Kuddoru* (Pavo)	4. *Pari Burea-doge* (Southern Cross)
5. *Upe* (Scorpio)	5. *Tuwagou* (Unidentified)
6. *Pari Burea Doge* (Southern Cross)	6. *Kudoro* (Pavo?)
7. *Jeriguigui* (Corvus? Orion?)	7. *Bika Joku* (Mars)
8. *Jecurireu* (Venus)	8. *Jerigigi* (Orion? Corvus?)
	9. *Upe* (Scorpio)
	10. *Bokodori Jari Paru Kado Jebage* (?)

NOTE: Version A is from Colbacchini and Albisetti;[5] Version B is from EB2.

americana). Subject matter is not differentiated in any noticeable way between the two categories of constellations, both of which include animals and cultural artifacts. At present, the list of Bororo astronomical knowledge cannot be used to its full potential, since there has been no specific investigation concerning the entire system of Bororo astronomy and its relation and integration with the cultural whole.

Two versions of a myth that tells of the naming of the stars and constellations are recorded by the Salesians.[8] In these versions, the *Aroe Kogae Kogaedoge*—certain spirits of the forest—name successive celestial bodies and configurations as they rise above the horizon to a boy of the *Baadajebage Čebegiwuge* clan (see FIGURE 1) who is hiding in a tree. TABLE 2 presents the two lists in a sequenced format for comparative purposes. There seems to have been a fair amount of free variation in the order of recitation of the names by the myth teller, a phenomenon by no means incompatible with what is known of myth around the world. What the order or sequence given represents to either the hearer or the teller of the myth is uncertain, since these sequences do not necessarily correspond with what one would find through direct empirical observation. In Version A, for example, *Kuddoro*, a dark blue macaw corresponding to a part of the constellation Pavo (in itself an interesting coincidence, since Pavo means "peacock," another fowl or bird), would rise some 15 hours after the "herons," or Orion's belt, while the following constellation of *Upe*, if correctly identified as including the star Antares, would already have been up in the sky. There is also the problem that not all of the observations of these risings would be possible in a single

night. However, if the list does in some way suggest a sequence of risings, it might clarify the confused identification of the Bororo constellation of *Jerigigi*. The *Enciclopédia Bororo* identifies its head as Rigel of Orion, which would be totally incompatible with the sequence of appearances recorded in the myth. However, an identification of the same constellation as Corvus, as is given in the earlier Salesian work, would result in at least an empirical verifiability. Unfortunately, the Bororo astronomical data lack a trustworthy control that would allow one to verify identifications or resolve contradictory elements. If there is an internal consistency to the orders of names that are given in the myths, this consistency could be based upon anything from a heirarchy of pragmatic importance to an individual myth teller's preference. It can be suggested that the celestial entities common to both versions, however, include those more culturally relevant: *Bika Joku*, Mars; *Jekurireu*, Venus; *Akiri-doge*, the Pleiades; *Bače Iwara Arege*, Orion's belt; *Pari Burea-doge*, the Southern Cross; *Kudoro*, Pavo (?); *Upe*, Scorpio; and *Jerigigi*, Corvus (?).

There is no doubt that the Bororo are aware of the phenomenon of heliacal rise, or the first appearance of a star on the horizon before dawn after a period of disappearance, and that they used their observations of such events in time-reckoning. The best example we have of this concerns their observations of the *Akiri-doge*, or Pleiades. The Salesians report that this star cluster first appears on the horizon before dawn towards the end of June after its brief disappearance. This occasion is used by the Bororo to celebrate the feast *Akiri-doge E-wure Kowudo*, that is, "Burning the feet of the Pleiades."[9] This ceremony, in which everyone is said to participate, consists of dancing and singing around a large fire, which is leaped over at certain moments in the celebration. By so doing, the Bororo sympathetically burn the feet of the Pleiades with the hope of slowing the progress of the star group and so prolong the dry season, the most favorable and productive time for their subsistence treks. Apparently, the Bororo intimately connect the Pleiades with the dry season, although this season usually begins in May; their heliacal rise, however, may have signaled the beginning of the period established for their seasonal treks.

To discuss Bororo concepts of time necessitates reference to two other celestial entities, the sun and the moon. These are the *Meri-doge*, the brothers Sun, *Meri*, and Moon, *Ari*, on whose relative positions (and phases) most considerations of Bororo astronomical time are based. Bororo mythology as recorded by the Salesians relates a substantial

number of episodes concerning these brothers and their numerous adventures on earth. *Meri*, Sun, is depicted as particularly powerful, reviving himself once and his brother *Ari* thrice from death. Moon's multiple deaths and resurrections and Sun's power of regeneration may be expressing Bororo ideas relevant to the characters of the celestial bodies. The Salesians, however, are wary of making connections between the mythical characters *Meri* and *Ari* and their celestial counterparts, despite the above characterization and a specific myth that tells of the Bororo of the *Karao Kujagureu* subclan of the *Iwagudu* clan causing the *Meri-doge* to rise into the sky by blowing them there with fire fans; the *Meri-doge* were literally "too hot" to be allowed to stay on earth.[10] In fact, the brothers Sun and Moon were blown into the highest of three levels of sky conceived of by the Bororo: the lowest, closest to earth is *baru kigadureu*, "white sky," the middle layer is *baru kujagureu*, "red sky," and the highest, that into which Sun and Moon were blown, is *baru kaworureu*, "blue sky." The layers are inhabitated by spirits of various types who exist in complicated relationships with each other and various other entities, including the Bororo themselves.[11]

One of the myths of the *Meri-doge*'s sojourn on earth describes an excursion they take through the countryside. During the trip they encounter various animals, which flee at the sight of them, "down the road of *Bakororo*." that is, of the West.[12] TABLE 3 presents the animals in the order in which they are encountered, including a sequence of felines, another of eagle-type birds, and several miscellaneous animals, totaling eleven. The myth as told has a definite rhythm and repeated refrain, which is broken at two different points in its narration. The first is early in the myth after the jaguar flees from the brothers; since the first category of animals is that of felines, we might suggest that the puma would have been the second cat encountered, as it appears in other contexts as one of the group of "felines," ordered heirarchically between the jaguar and the ocelot.[13] The second "break" seems to occur between the herons and the parakeets, and so might be a member of a bird category. If these two breaks—or only one of them—were filled, the number twelve or thirteen is arrived at as the total number of encounters and animals that flee down the path of *Bakororo* in the West. The number and the reference to westward-moving entities are both suggestive of calendrical concepts, the former being the number of synodical lunar months in a year and the latter possibly referring to the setting of celestial bodies (e.g., constellations seen to resemble the corresponding animals). The Bororo term for month is simply *Ari*, "moon", and they name two

TABLE 3

ENCOUNTERS ON THE ROAD OF *BAKORORO* BY THE *MERI-DOGE*

1. Jaguar (*Felis uncia*)
2. (possible break in sequence)
3. Ocelot ("Jaguartirica"; *Felis pardalis*)
4. "Suçuaruna" (*Felis concolor*)
5. Caracari eagle (*Milvago chimango*)
b. With fledgling
6. Royal eagle (*Thrasaetus arpya*)
b. With fledgling
7. Great eagle (?)
b. With fledgling
8. Little eagle (?)
b. With fledgling
9. Heron (*Ardea* sp.)
10. (possible break in sequence)
11. Parakeets (*Pyrrua vittata*)
12. Monkeys (possibly *Alouatta* sp.)
13. Cayman (*Caiman* gen.)

NOTE: This table is taken from myth 56 of EB2.

seasons, *erubutu*, the dry season, and *bubutu*, the rainy season. Although the Salesians report no longer period of time named or categorized by the Bororo, we have already seen that the concept of heliacal rise, an annual event, was quite familiar and important to the Bororo, and it is unlikely that, having such knowledge, they would not then recognize the solar year and *Meri*'s annual movement between the solstices or its division into twelve or thirteen periods based upon lunar positions or phases. This seems especially likely with the many mythic referrals to the death of *Ari*, Moon, and his "rebirth" through the ministrations of Sun. Their visualized scheme of months may have found expression in a list of names not unlike that of the excursion myth, even if such names were not specifically numbered. Although Bororo counting was based upon a distinction between one, two, and "many," Lounsbury points out that a binary system is at the core of all counting systems,[14] and so the Bororo were not necessarily "unscientific" in their approach to calculations past the number two.

An internally ordered list of months, if composed of animal references, might correspond to a coherent, observationally based pattern of faunal cycles in the Bororo area. In the myth of the excursion by Sun and Moon, the eagle-type birds are encumbered with fledglings that cannot fly. The example is suggestive of an awareness of breeding cycles;

such information would have allowed the optimal exploitation of the environment for food resources and other commodities useful in Bororo life. In addition, this myth, although referring to only a few specific landmarks, is the description of a journey of Sun and Moon. Toward its end, the brothers ascend the hill of *Čibae E-iari*, a sacred, steepsided, table-topped elevation that is pierced with holes in which macaws were found to nest and so were hunted, and in which, also, the Bororo interred their dead (the extent of this custom is not known, nor is it known for which members of the community it was reserved; the practice apparently ended when the Bororo feared the disturbance of the remains of the deceased by the whites).[15] Once the *Meri-doge* reach the summit of this hill they descend, and from its foot proceed to the São Lourenço river. At or from this point they finish their excursion; the myth ends with the words, "and then they arrived again at the beginning of their road (way)," as if, after their eleven, twelve, or thirteen encounters, marked in the area by certain geographical configurations and connected with specific animals, they have come full cycle back to their starting point. It is as if to say the celestial *Meri-doge* had completed a year's movements along the horizon and through the sky, marked by the setting of celestial forms in the west, and were ready to begin it again.

DISCUSSION

The data collected to date on the Bororo, even though not focused upon matters of astronomy or timekeeping, have demonstrated that the Bororo possess a rather extensive and intimate knowledge of the celestial sphere. Lévi-Strauss reports that, while he was with the Bororo, "the nights were given over to religious ceremonies, and the natives slept from dawn until midday."[16] Whether these nightly religious ceremonies resulted in the Bororo interest in the night sky, or vice versa, is too simple a question. If the Bororo were primarily agricultural, there would be little to oppose the assumption that their nightly ceremonies and vigils went hand-in-hand with the making of astronomical observations by which they could more readily plan and order their plantings and harvestings, and their ritual cycles as well. McCluskey has explained in succinct terms the expected dependence of agriculturalists upon the fixed and recurring celestial cycles.[17] The literature on the Bororo tends to stress their positions and abilities as hunters extraordinaire, although house gardens of spices and various domestic products can be assumed to have played a role in their diets, as in those of other lowland groups. It is

not the aim of this paper to demonstrate that the Bororo either were or were not primarily dependent upon agricultural food products for their subsistence. If they were primarily hunters, fishers, and gatherers, as most of the literature reports, and assuming they could provision villages with at least 140 extended family houses,[18] then they would have needed access to a rich and varied ecosphere, and must have possessed the knowledge and skill to adequately exploit it. Geographically it is established that, in aboriginal times, Bororo villages were located with just such an access. However, for the highest yield from an environment it is not only important to know what, where, and how to hunt, fish, and gather, but also when.

The use of constellations that represent animals to mirror or signal the life cycles of their terrestrial counterparts has already been demonstrated by Urton in the Andes.[19] Although the Andes as a culture area were principally and very successfully agricultural, the system of astronomical observations that served to order the seasonal rounds for planting and harvesting were detailed enough to incorporate observed faunal cycles. The work of Urton, Zuidema, and Aveni is demonstrating the use of a complex system of astronomical oberservations to order Andean time and space and their relation to urban organization, social structure, ritual, and subsistence.[20] Andean urban organization is based upon the *ceque* system, a series of directional lines radiating outwards from a ceremonially important center.[21] The ceremonial complex at the center of this system includes the sacred space of temple and plaza, from which astronomical observations were made and which served important functions during the performance of rituals. This sacred area also served to unify the two moieties that characterized Andean social structure, as well as differentiate them. The *ceque* lines were often, if not always, oriented towards a locally important geographical feature, often connected with the local irrigation system, behind which was the rising or setting of some celestial body. These observations were bound up in a complex calendar system to regulate every major facet of Andean life, and were further integrated in the system of spatial divisions (in Quechua, the same word, *pacha*, signifies both "time" and "space"). We know that, among the Inca, these spatial divisions in the environs of Cuzco were ministered to by specific clans at specific times of the year, thus integrating social structure with calendarical and spatial organization.

Although neither urban nor agricultural, Bororo culture has certain structural similarities to the Andean scheme. The eight major Bororo clans are spatially ordered in a fixed manner around the central men's

house and ceremonial plaza, both sacred precincts. When villages were larger and consisted of concentric rings of houses, the clan orientations were maintained, structurally resembling the clan and *ceque* relationships in the Andes. The Bororo paths are similar to the Andean road system, which ran out from a town's center to the four principal directions.

In the Andes and elsewhere, the progress of the sun and, at times, the moon is marked through observations of their rises and sets from some fixed point. The excursion myth of the *Meri-doge* seems to relate the same or analogous practice among the Bororo, who marked the position of these bodies over at least one sacred hill and with respect to the course of a river. Fortunately, we have rather good data and a sound base of investigation in the Andes, and so rich and credible material. Unfortunately, a comparable base has yet to be established for the Bororo. It is not the purpose of this paper to present the Bororo case as if it were an offshoot of the Andean situation, or even to imply the reverse, although some of the early Bororo literature mentions the possibility of Bororo-Andean contact and connections.[22] However, the Andean scheme can serve as a good frame with which to approach the investigation of the Bororo system.

In the Andes, mythic contexts have been interpreted for their astronomical information, for calendrical cycles encoded within them, and for related information of the social organization.[23] The scheme of observations involving the constellation of the celestial ("black") llama and its eyes, a and b Centaurus, and oppositions involving major constellations such as the Pleiades, Orion, and the tail of Scorpio may all have their counterparts in Bororo culture. The *Pari* constellation in the Milky Way of a running emu is undoubtedly comparable to the figure of the black llama, while the Pleiades, Orion, and Scorpio are all prominent in the Bororo stellar data. However, we still lack enough analysis—if not information—to describe their calendrical functions. Perhaps the analysis of texts of myths can also produce more results. One Bororo myth concerns a protagonist named *Jerigigiatugo* (c.f., *Jerigigi*, TABLE 1), who is connected with the advent of high winds and heavy rains (Lévi-Strauss uses this myth as his "key" myth in his Science of Mythology series[24]). We might immediately connect the constellation, therefore, with the beginning of the rainy season, and even go so far as to connect this to the *Paiwoe* clan, of which the character *Jerigigiatugo* is a member, with this seasonal occurrence linked to the clan's location. If the constellation *Jerigigi* were a part of Orion, it might be seen to rise directly behind the clan houses of the *Paiwoe* group as viewed from the central

plaza or men's house; this could be a consistent scheme with other constellations and the observations of their risings and/or settings also related to clan space and a temporal cycle. However, *Jerigigi* itself is not positively identified; it may be Corvus and not part of Orion, and so not rise through *Paiwoe* space. Although the approach used in this argument can be a productive one, there is no firm base from which it can be consistently applied.

It is interesting to note that both the stars and the sun and moon pertain to the *Baadajebage* clan. Again, the data is contradictory, but this "super"-clan is probably located just north of both the east and west points of the village circle and may symbolically represent the major axis of celestial movement (which is structurally reversed by the flow of most waterways in the Bororo area). It is pertinent to connect the *Baadajebage* clan as the "first" clan of the village and as the "constructors of the village"—as the word is glossed—in which we see a direct relationship between the laying out of the village plan and its basis in empirical astronomical observation.

Although the Andean model was used in comparison to that of the Bororo, rather complex schemes of astronomy are reported for other lowland groups, which, however, differ necessarily in terms of technical specifics from those practiced in the highlands. The French Capucin monk Claude D'Abbeville lists a substantial number of stars and constellations that were used by precontact Tupinamba along the Brazilian coast to order their year.[25] Sightings included series of heliacal rises to warn of seasonal changes, while Huxley reports similar sightings with connections to the ritual cycle of probable Tupinamba descendants.[26] Other work in the lowlands, including that of Dumont, Hugh-Jones, Reichel-Dolmatoff, Whitten, and Lévi-Strauss, has shown the importance of astronomical and/or directional concepts with time and their integration into the total life of the culture.[27] Unfortunately, in most cases of such work, a sound methodology of empirical observations and identifications underlying theory has neither been a principal concern of the investigators nor been adequately expressed by the natives or the anthropologists. It is also obvious that not all cultures impart equal significance to corresponding environmental and cultural phenomena, so that detailed systems of astronomical knowledge should not always be expected. However, once such a system is recognized, it is necessary to refrain from making judgmental comparisons with Western or other "sophisticated" schemes of astronomy. Each system needs to be understood in terms of the broader cognitive and symbolic systems of which it is a part.

With the Bororo we have an excellent case in point. Even at the base conceptual level, the Bororo (*Boe*) show themselves to be intimately aware of astronomical time. Their village organization is predicated upon space and directionality, which are linked to social organization, while the village as a whole serves to integrate and define "religious ideas, marriage laws, hunting, fishing, public ceremonies and funeral rites."[28] Their observations of faunal and floral cycles may find expression in their system of observed astronomical phenomena, and are also linked to the social groups: all fauna, for example, seem to have belonged to one or other of the Bororo clans.[29] We are just beginning to appreciate the complexities of these organizations and interactions with their intricate integrations of all aspects of Bororo culture.

CONCLUSIONS

A preliminary investigation of Bororo culture as reported in the literature has yielded a rich body of astronomical data. This aboriginal system included the observation of stellar bodies, including individual stars, star-to-star constellations, "black" constellations in the Milky Way, planets, the sun, and the moon. Such observations were concerned with positions on or appearances over the horizon and relative positions in the sky, including that of the zenith. These positions were used as time indicators on a daily, monthly, seasonal, and yearly basis; the longer cycles recognized included stellar heliacal risings, the solar year, a wet and dry season, and probably at least a synodical lunar year (if not a sidereal one; the data will not yet support a more definite statement). This astronomical system was used to order the yearly round of activities and was probably correlated to local faunal and floral cycles. It was also the basis of village organization; that is, with clan directionality and position. This, in turn, served to integrate and define moral codes, exchange patterns, ritual performances, and rules for intergroup relationships. The general scheme of this system appears to correspond well with what is known of other systems of tropical astronomy in the Americas.

Further field research and analysis of textual data, combining a basic methodology of observation and the recording of Bororo astronomical practices and their seasonal rounds is necessary before the Bororo astronomical model can be adequately described. However, such a description and its analysis is not isolated from the cultural model as a whole; rather, appeciation and comprehension of the system can only be gained through the study of it as it lies imbedded and integrated in the broader symbolic and cognitive systems of the culture.

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Astronomical Alignments in Medieval Islamic Religious Architecture

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SINCE THE EARLY days of Islam, Muslims have faced the sacred Ka'ba in Mecca when praying. With the advent of Islam, Mecca became the navel of the earth in Islamic tradition, and the Ka'ba, a pre-Islamic pagan shrine of uncertain origin and date, came to be a focus, if not an object, of veneration.[1] Thus, for centuries, mosques have been built so that they are aligned towards Mecca, the *mihrāb*, or prayer-niche, indicating the *qibla*, or local direction of Mecca.[2]

From the eighth century onwards, Muslim astronomers devoted much attention to the problem of determining the *qibla* of any locality from the geographical coordinates of Mecca and of that locality.[3] They derived geometric and trigonometric solutions of considerable sophistication, and even compiled tables displaying the *qibla* for each degree of latitude and longitude. They also devised approximate methods with which the *qibla* for any locality could be found easily and accurately enough for all practical purposes. Such approximate methods for finding the direction of Mecca were widely known in the medieval Islamic world from the ninth century onwards, and most medieval Islamic astronomical handbooks (*zījes*) contained chapters on the determination of the *qibla* by mathematical means, as well as geographical tables displaying latitudes, longitudes, and *qiblas* of important cities.

The legal aspects of the religious duty of Muslims to face Mecca in prayer, and the mathematical techniques that were available for finding the *qibla*, are now rather well documented in the modern scholarly literature. There are, however, other pertinent questions relating to the

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qibla, the answers to which lead to rather exciting new areas of research.[4] First, for example, how could the earliest Muslims, innocent of any knowledge of geography, let alone the exact sciences, have determined the *qibla*? Second, why are so many medieval mosques, according to modern historians of Islamic architecture, not properly aligned towards Mecca? And third, how can one account for a substantial corpus of medieval Islamic literature on "folk astronomy," in which instructions are presented for finding the *qibla* by means of the sun, the stars, and even the winds?

The earliest *qibla* determinations were, in fact, associated with the risings and settings of the sun and fixed stars, and mosque orientations in the seventh and eighth centuries, and even thereafter, were made by astronomical alignments. Thus, for example, some of the earliest mosques in Egypt and Andalusia faced the rising sun at midwinter, and some of the earliest mosques in Iraq, Iran, and Transoxania (Central Asia) faced the setting sun at midwinter. Directions perpendicular to the solstitial directions were also used. Cardinal orientations were popular as well, even where they were really quite inappropriate. Occasionally, of course, mosques were built on the sites of churches and pagan temples, without modification of the orientation of the earlier edifices.

The astronomical orientations of these early mosques were often used for mosques built later in the medieval period, even though the "correct" mathematically determined *qibla* was then available. Many Islamic cities had several accepted *qiblas*; this we know from medieval Arabic historical, legal, and astronomical texts, as well as from the surviving monuments. Also, entire cities with more-or-less orthogonal street plans were sometimes laid out facing either an accepted astronomical orientation for the *qibla* or a mathematically computed *qibla*. Religious architecture in these cities could thus be aligned with the street patterns. More commonly, mosques would be oriented to the *qibla* regardless of the street patterns, or would be aligned externally with the street patterns and internally with the *qibla*.

The old city of Cairo presents a particularly interesting case study. The city was founded in the tenth century alongside the Pharaonic Red Sea Canal. The canal, the direction of which was dictated by local topography, is fortuitously perpendicular to the *qibla* used by the first Muslims in Egypt in the seventh century, which was towards the winter sunrise. The more-or-less orthogonal street plan of the old city was thus aligned towards the winter sunrise. The religious architecture erected in the old city in later centuries is, in the main, externally aligned with the

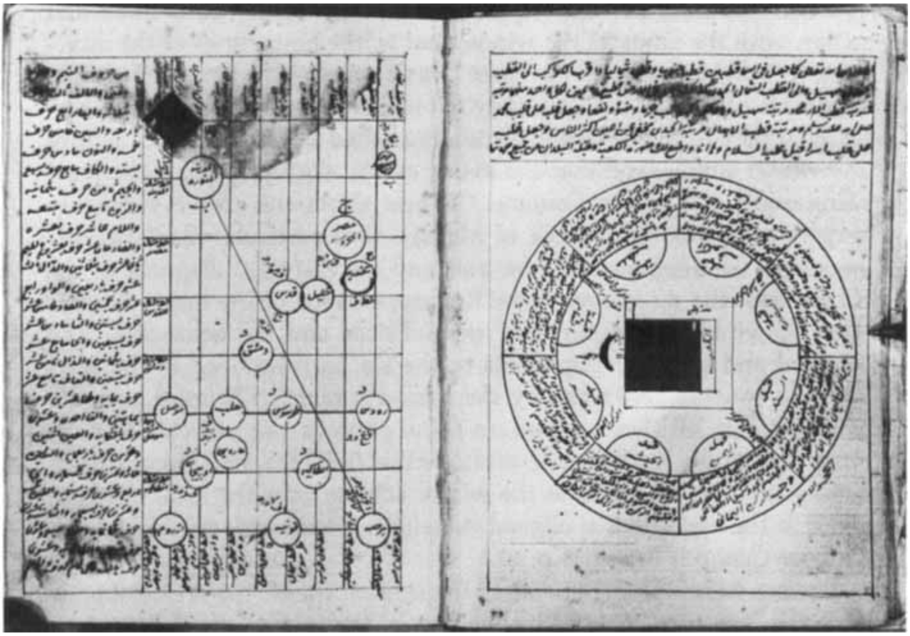

FIGURE 1. Diagrams in a treatise of uncertain provenance on the *qibla* and the Ka'ba contained in a seventeenth-century Egyptian manuscript. The diagram on the right identifies eight regions of the earth about the Ka'ba, and states which astronomical directions one should face in each in order to be standing in the *qibla*, as well as which part of the circumference of the Ka'ba is associated with each region. The diagram on the left shows various localities on a latitude-longitude grid and their positions relative to the Ka'ba. Notice that the Ka'ba is shown inclined to the meridian.

street plan, but the interiors of these mosques and madrasas are twisted to face the *qibla* determined by the astronomers, which differs from the direction of winter sunrise by 10°. The choice between the various available *qibla* directions in a city sometimes varied according to the particular legal school. Thus, for example, in Samarqand, one school, the Shafiites, favored due south whilst another, the Hanafites, favored due west; meanwhile, the main mosque in the city was aligned towards the winter sunset and the astronomers advocated yet another direction for the *qibla*.

A corpus of medieval Arabic texts dealing with folk astronomy, recently investigated for the first time, explains these solstitial, perpendicular to solstitial, and cardinal orientations in terms of the notion of a world divided into eight or twelve sectors about the Ka'ba (FIGURE 1).[5]

The same sources associate astronomical alignments, both solar and stellar, with the limits of the winds, that is, the boundaries of the directions from which they blow. These texts point even to the astronomical alignment of the Ka'ba itself; they tell us that the minor axis of the rectangular base of the Ka'ba is solstitially aligned towards summer sunrise and winter sunset, and that the major axis is aligned towards the local rising point of the star Canopus.[6] (These directions are very roughly perpendicular for the latitude of Mecca). One particular medieval text associates the alignments of the axes and the east-west diagonal of the Ka'ba with the directions of the first appearance of the lunar crescent after sunset about the times of the solstices and the equinoxes. The solstitial and Canopic alignments of the Ka'ba mentioned in the texts are only roughly confirmed by the available plans. The most accurate available map of Mecca, based on aerial photography, reveals that the minor axis of the Ka'ba is aligned (to within 0.5°) towards the southernmost setting of the moon at the winter solstice over the local horizon, and that the major axis is aligned (to within 2°) towards the local rising point of Canopus (epoch A.D. 0).[7]

The astronomical alignments of the sides of the Ka'ba are associated in certain medieval texts with the limits of the four winds (FIGURE 2). I suspect that this association reflects a pre-Islamic meterological tradition, and do not find surprising the fact that such a tradition is recorded only in books on folk astronomy and the determination of the *qibla* rather than books on the history of Mecca. Yet other medieval texts point to the physical associations of the Ka'ba (FIGURE 3), but these are relatively late and should not be taken to represent original conceptions about the sanctuary. Nevertheless, I suspect that the close correspondence between the actual orientation of the Ka'ba and the astronomical orientations mentioned in the texts is not fortuitous, and I am currently inclined to think that the Ka'ba may have been intentionally laid out in accordance with a wind theory. There is no mention of the specific lunar alignment of the Ka'ba (which was first noted by Dr. G. S. Hawkins) in any known medieval texts, and I have no evidence beyond the accurate lunar alignment of the minor axis of the Ka'ba to lead me to anticipate any association with the regulation of the lunisolar calendar of the pre-Islamic Arabs.[8] The alignment of the Ka'ba should, of course, not be considered in isolation but, rather, in the context of other sites with possible astronomical orientations, namely those in Northern Arabia (especially Nabatean sites),[9] Central Arabia (especially some hitherto unexplained stone circles),[10] and Southern Arabia (especially an-

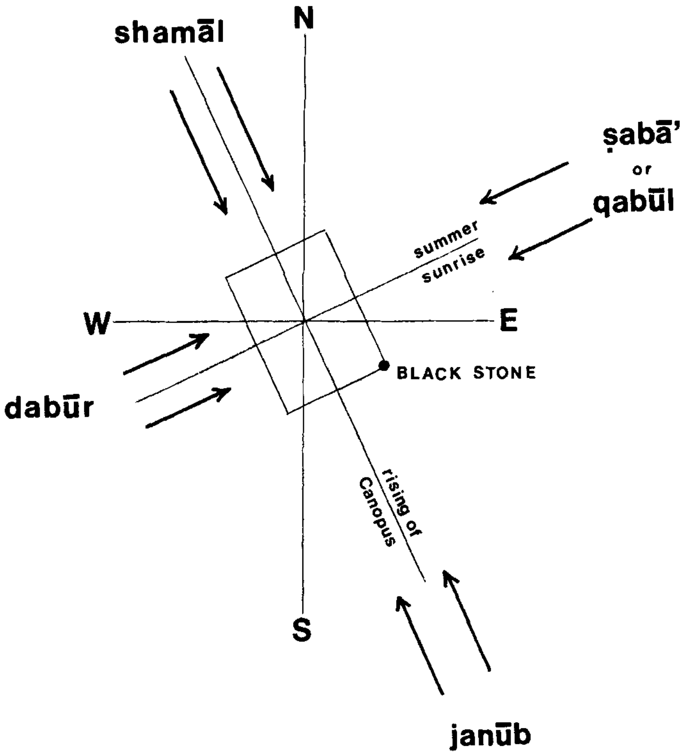

FIGURE 2. The astronomical alignments of the axes of the Ka'ba as described in the medieval Arabic sources, showing their relationship to the four winds. This relationship is recorded, for example, in al-Bīrūnī's treatise *al-Tafhīm*. The astronomically defined limits for the winds are recorded, for example, in E.W. LANE's *Arabic-English Lexicon*.

cient temples associated with astral worship, as well as more primitive rings and lines of stones).[11] None of these have been properly investigated yet.

The possibility that the Ka'ba is astronomically aligned in accordance with a wind theory calls to mind the more sophisticated octagonal "Tower of the Winds" in Athens, which Vitruvius tells us was built in the first century B.C. as an architectural representation of an eight-wind system. As we now know from the recent investigations of Prof. Derek de Solla Price of Yale University, the Athenian Tower was far more than that. In the light of recent archaeological investigations and new textual evidence, Price sees the tower as an architectural representation of "an interlocking set of theories covering virtually all creation and comprehend-

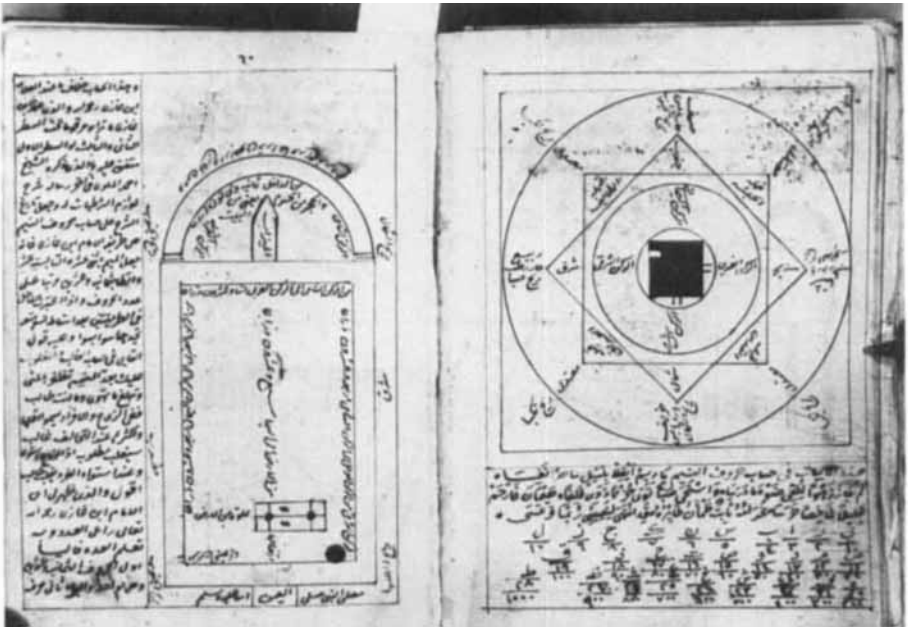

FIGURE 3. Two more diagrams in the same treatise mentioned in the caption to FIGURE 1. The one on the right shows the Ka'ba at the center of two superimposed squares usually associated with the representation of the four elements and their qualities. The seasons and their associated weather conditions, the winds, and the *qiblas* of four main geographical areas are featured in this diagram. The diagram on the right shows, in an exaggerated fashion, the rectangular base of the Ka'ba, with the Black Stone set in its southeast corner.

ing cosmology, chemistry and physics, meteorology, and medicine."[12] There is also evidence that public clocks in the Graeco-Roman world, incorporating either anaphoric dials as contained in the Tower of the Winds or sundials, were intended to represent the universe as well as to display the time of day. Further research on the Nabatean sites of Northern Arabia and Jordan may provide evidence of some connection between the Tower of the Winds as a microcosm of the Greek universe and the Ka'ba as a microcosm of the Arab universe. A first-century Graeco-Roman sundial is already known from one Nabatean site in Northern Arabia.

The relationship between the Ka'ba and the north and unfortunate left-hand side and the south and fortunate right-hand side has already been discussed by J. Chelhod.[13] Implicit in these associations is that one should be facing the rising sun, or the southwest wall of the Ka'ba. In-

deed, in this position one is facing the wind called in Arabic *qabūl*, which blows from the direction of summer sunrise. The term *qibla* (based on a root q-b-l) appears to have originally denoted the direction in which one stood to face (the Arabic verb is *istaqbala*, based on the same root) the *qabūl* (also based on the root q-b-l). Furthermore, when one stands in this direction, one is facing one of the two favored directions of the pagan Meccans, whose round houses we know from the medieval sources were opened to this direction. W. Barthold has argued that the earliest mosques in the Hijaz faced east, but attributed this to Christian influence;[14] rather, if indeed they faced east, this is perhaps to be seen as a residual effect of the predilection of the pagan Arabs for the east. The *qibla* was soon changed to the south for these mosques in the Hijaz, in order that they should face Mecca. It appears that the alignment of the major axis of the Ka'ba was also important: the pagan Arabs favored the south because the south wind brings rain in the Hijaz. The Black Stone, the most sacred of several stones that were once venerated at the Ka'ba, is set in the southeast corner of the edifice, facing the east (determined by summer sunrise) on the one side, and the south (determined by the rising point of Canopus) on the other.

Certainly the Ka'ba also follows the tradition of the Semitic baetyls or sanctuaries of the ancient Near East.[15] It is built by the sacred spring of Zemzem in a valley flanked by sacred hills. It houses a sacred stone, and originally housed more of the same. In the decades before the ascendance of Muhammad, the Ka'ba is said to have contained some 360 idols of various gods, and it seems to have been associated with the worship of the sun and moon at some stage in its history: images of both the sun and moon were part of the paraphernalia associated with the Ka'ba before the advent of Islam.[16] We now know that the rectangular base of the Ka'ba is astronomically oriented. This orientation may have been deliberate, either to face the building to the winds or to the southern limit of the setting moon. On the other hand, the astronomical alignments of the sides of the Ka'ba may also be quite fortuitous. They may have been noticed by the early Muslims and used to facilitate *qibla* determinations.

The first Muslims – who built mosques as far apart as Andalusia and Central Asia – could not have known the actual direction of Mecca, but they were aware, I think, that the Ka'ba, which they wanted to face, was oriented in a certain way. Thus, they knew that, when facing a particular wall or corner of the Ka'ba in Mecca, one was facing a particular solar or stellar rising or setting point; they assumed that, away from Mecca, if one faced in that same astronomical direction one would still

be facing the same wall or corner of the Ka'ba. Each wall or corner of the Ka'ba was associated with a specific region of the world, and so the *qiblas* in these regions were astronomically defined. Such associations are mentioned in one tenth-century text, but I suspect that they originated somewhat earlier. Two independent medieval texts, one from the eleventh century and the other from the thirteenth, tell of a religious scholar from Samarqand who went to Mecca to verify that the *qibla* in his home city was indeed towards the winter sunset, and of an Egyptian who went to Mecca to verify that the *qibla* in Cairo was indeed towards the winter sunrise.

Only a preliminary study has been made of mosque orientations, this based on all available plans in the modern scholarly literature.[17] Most of these are unreliable as far as orientations are concerned, and information is altogether lacking on local horizon conditions. However, some of the patterns that emerge can be explained in the light of the new material gleaned from medieval texts dealing with *qibla* determinations by non-mathematical procedures. Of particular interest are historical and legal texts that describe the various *qiblas* that were used in such localities as Central Asia, Egypt, the Maghrib, and Andalusia.

It is clear that the study of alignments in medieval Islamic religious architecture, as well, perhaps, as the various pre-Islamic Arabian sites mentioned above, constitutes an important new chapter in archaeoastronomy. Not a single Islamic or pre-Islamic Arabian monument has been surveyed yet with the rigor demanded by this relatively new discipline. Furthermore, only a very few of the relevant medieval texts are published, and none is yet available in any Western language. Nevertheless, there are ample indications that further research in this area will be worthwhile.

ACKNOWLEDGMENTS

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2. On the religious duty to face Mecca in prayer, see A.J. WENSINCK, "*Ḳibla* (ritual and legal aspects)," *Encyclopaedia of Islam*, 2nd ed.

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5. On this tradition of sacred geography in medieval Islam see D.A. KING,[4] *World*. Such diagrams are also found in certain medieval Arabic cosmographies already available in published form.

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12. On the "Tower of the Winds" in Athens, see D.J. DE SOLLA PRICE, *Science Since Babylon*, 2nd ed. (New Haven: Yale University Press, 1976), pp. 78-80, and the references there cited.

13. See J. CHELHOD, "A Contribution to the Problem of the Pre-eminence of the Right, based upon Arabic Evidence," (translated from the French), in *Right & Left*, ed. R. Needham (Chicago: University of Chicago Press, 1973), pp. 239-62, especially pp. 248-53. Although Chelhod assumed that the corners of the Ka'ba are cardinally aligned, and was not familiar with any of the sources used in the present study, he was able to recognize the function of the Ka'ba as a "microcosm of the universe." On the orientation of the Ka'ba see also B. FINSTER, "Zu der Neuauflage von K.A.C. Creswells *Early Muslim Architecture*," *Kunst des Orients*, vol. 9 (1972), pp. 89-98, especially p. 94. The notion that the pagan Arab Ka'ba was converted into a church with an apse facing Jerusalem is propounded in G. LÜLING, *Der christliche Kult an der vorislamischen Kaaba* . . . (Erlangen: H. Lüling, 1977), pp. 43-52. See also F. LANDSBERGER, "The Sacred Direction in Synagogue and Church," *Hebrew Union College Annual*, vol. 28 (1957) pp. 181-203. (Landsberger's plans showing synagogues and churches facing Jerusalem remind me of plans of mosques that show the *qibla* wall facing Mecca.)

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Ahu a 'Umi Heiau
A Native Hawaiian Astronomical and Directional Register

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BACKGROUND

IN RECENT YEARS an interest has developed in identifying native astronomical registers at various archaeological sites.[1,2] Although such registers have been reported from Oceania, none has been positively identified in Hawaii by actual alignment sightings. There is a hint of one such solstice register at Cape Kumukahi, Hawaii, in legend.[3,4]

A gap exists, then, in archaeoastronomic studies in Hawaii. The ancient Hawaiians, in spanning the Pacific Ocean during the migratory period, were seafarers who navigated confidently by the night sky.[5] They were a people who knew of the azimuthal positions of rising and setting stars, sun, moon, and planets. Not only did they search the sky for omens; they also used a farming and fishing calendar based on the cycle of the moon. Their culture reflects a knowledge of the sky. Yet, archaeologists have not found a definitive *heiau* that positively relates that knowledge.

A *heiau* is a Hawaiian temple, usually a walled enclosure resting on a paved platform (*kahua*). In Ahu a 'Umi Heiau may be found an astronomical-directional register that could provide insight into how ancient Hawaiians structured the sacred cosmos of the sky to a sacred space

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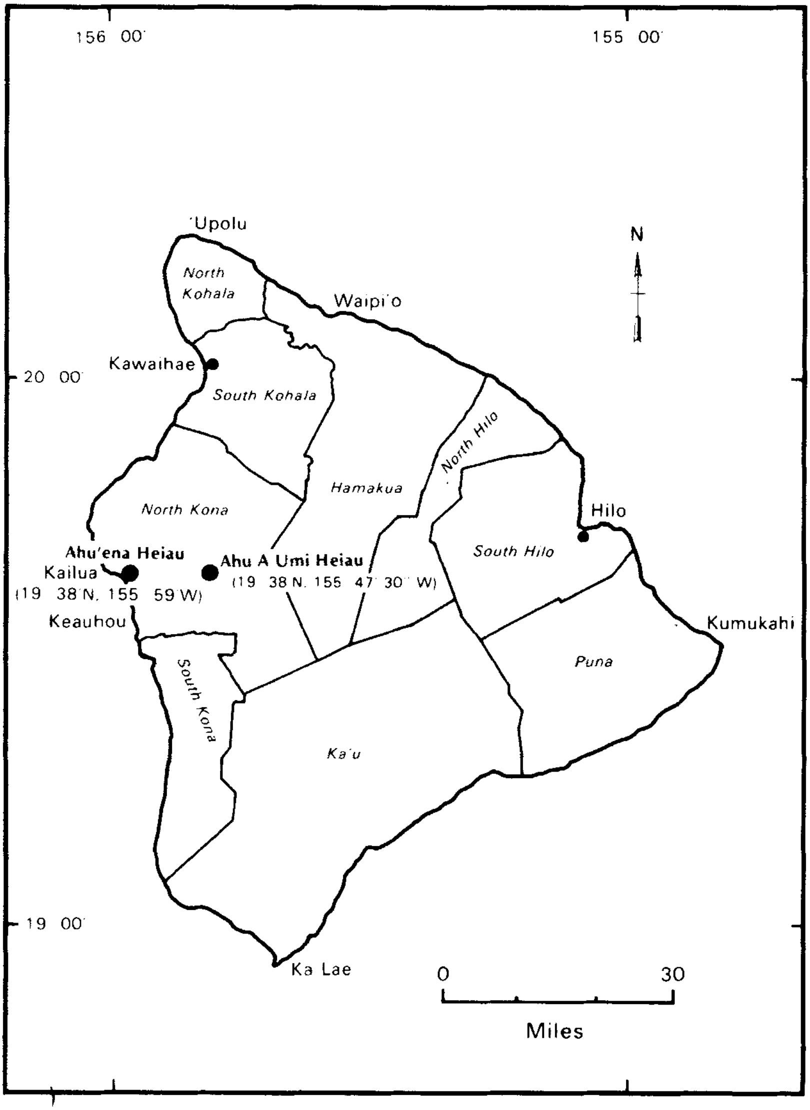


FIGURE 1. A location map of the island of Hawaii.

on earth. The Hawaiian word *ahu* means a "heaping," as of rocks, or a "gathering," as of people.

Ahu a 'Umi Heiau sits at an elevation of 1585 meters, on the high, flat saddle between the volcanoes Mauna Loa (4170 meters high) and Hualalai (2520 meters high). Mauna Kea (4205 meters high), the highest mountain in Hawaii, rises impressively to the northeast.

The *heiau*'s location is at 19° 38′ N, 155° 47½′ W. It is the furthest inland and the highest of all large, precontact (i.e., pre-European discovery period) *heiaus* in the Hawaiian Islands (FIGURE 1).

Native Hawaiian tradition claims that this *heiau* is that of 'Umi, a high-ranking chief who united eight districts under his rule some five centuries ago. Another ancient legend says that, after consolidating the eight districts, 'Umi undertook a census of his newly acquired territory, which included the whole island of Hawaii.

Since the priests participated in the king's census-taking, they were responsible for setting the dates of significant ceremonial events. Census-taking was a prelude to taxation, particularly after conquest, consolidation, and reapportioning of land. The noted Hawaiian chronicler, David Malo, informs us that the heliacal rise after sunset of the Pleiades in autumn heralded the beginning of the *makahiki* festival, when taxes were collected:[6]

> The Polynesian year, as stated by Ellis, Fornander, Moerenhout and others, was regulated by the rising of the Pleiades, as the month Makali'i began when that constellation rose at sunset, i.e., about November 20.[7]

Makemson also places the beginning of the *makahiki* at the rising of the Pleiades, "late November or early December," on the "new moon *after* the first appearance in the eastern sky in the evening twilight."[8]

THE STRUCTURE OF AHU A 'UMI HEIAU

The structure of the *heiau* is a complex of three parts: (1) a central rectilinear enclosure or *enceinte* 22.8 meters long by 17.4 meters wide, (2) eight cairns, or *ahus* of stones, irregularly spaced around this central *enceinte* on the north, east, south, and west, (3) a smaller stone enclosure to the west, the walls of which are 8.83 meters (N), 7.45 meters (E), and 6.75 meters (W). The southwest side of this smaller *enceinte* with its entrance is 8.44 meters long (FIGURE 2).

In 1840, men from a United States Navy Exploring Expedition conducted the first survey of Ahu a 'Umi. The survey map showed an ar-

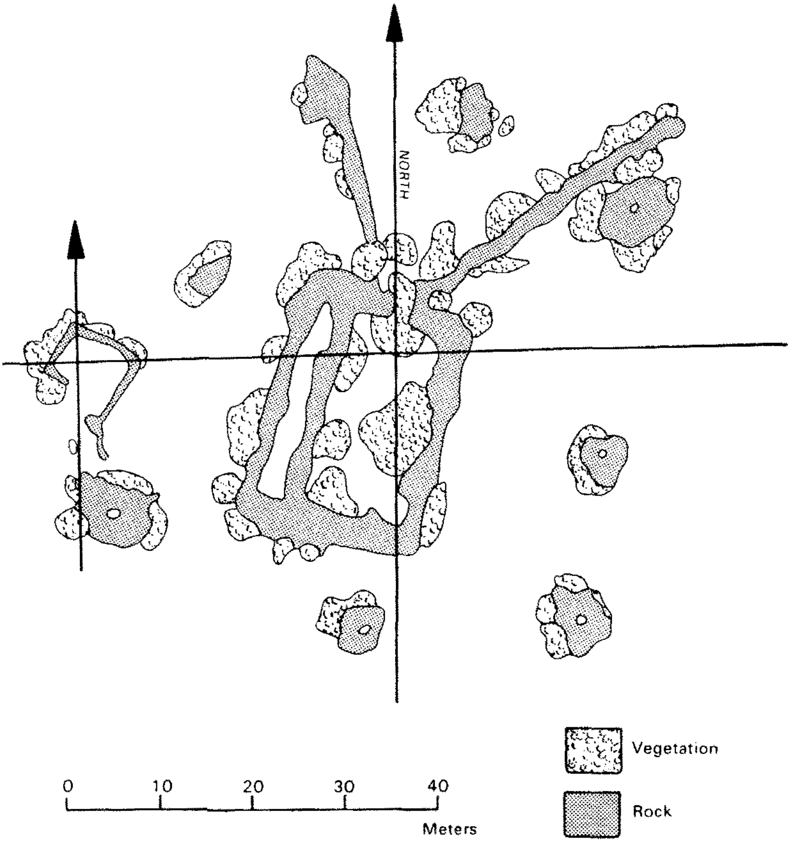


FIGURE 2. A directional and scaled baseline map of the Ahu a 'Umi Heiau complex.

rangement of cairns around a central enceinte with inaccuracies in both spacing and location.[9] The surrounding cairns were described as flattop pyramids with bases wider than the tops. These generally fit the description of astronomical platform observing sites in the Gilbert Islands:[10]

[8]*Buatarawa*. A *buatarawa* was a platform built up of large stones, upon which the Gilbertese male of adult years performed the magico-religious ritual known as *te kauti*. The base of such a platform would measure from 3 to 4 feet square; its height would vary between 2 and 12 feet; its sides tapered inwards very gradually from base to summit. The summit was flat, being levelled off with fine shingle, in order to afford a sitting-place for the person performing the *kauti* ritual. A *buatarawa* was placed by preference

> on the eastern side of an island, but any site which commanded an eastern horizon was considered satisfactory. The ritual of *te kauti* was performed at the point of dawn, facing the sunrise.

The arresting feature of the expedition diagram, called the "Wilkes's map," is a central corridor (which does not exist today) running in and through the central *enceinte*. A ground search conducted by our archaeological field team yielded no evidence of its existence.

About a hundred years ago, stones were removed from some of the cairns to construct stonewall extensions from the northern wall outwards, probably for herding livestock into the central enclosure. Portions of the cairns and the central *enceinte* are in dismantled condition.

However, and this is important, while some cairns and walls appear to be in disarray, owing to decades of neglect in an area prone to shuddering earthquakes and, in recent times, to inadvertent vandalism through minor resetting of stones, the complex appears, on the whole, to have maintained the geometry of its arrangement and its basic form. This structural integrity is most apparent when viewed from above.

FIELD OBSERVATIONS AT 'UMI'S HEIAU

In March 1980, we took aerial photos of the *ahu*. These photographs were subsequently used to produce a map of the *heiau*. An understanding of the *heiau's* function as an astronomical register would depend upon: (1) knowing the north-south baseline, (2) having a scaled base map of the whole complex, and (3) relating the azimuthal bearing of cairns to the azimuthal positions of rising and setting stars, sun, and moon. For this we must start from the pivotal vantage point, a center.

At the summer solstice we noticed that the sun rose behind the northeast cairn (subsequently labeled "Cairn B"), from a vantage point not at the center of the *enceinte* but closer to its northern door. We then asked ourselves, If the central *enceinte* did not exist, where would the spatial center of the complex be located, based on procedures used in *heiau* construction? The arrangement of 'Umi's *heiau* suggests that it was designed according to prescribed rules for constructing a symbolic design of the cosmos on earth.

Our first task was to plot the north-south base line by taking transit sightings of Polaris, using it as our reference star. At the autumnal equinox, we noticed that the western corner junction of the smaller-outside enclosure had a pointedly true east-west orientation. An extension of a line on this orientation would intersect our north-south base

TABLE 1

Cairn	*Azimuthal Reading*	*Associated Astronomical Feature*
A	22°	
B	65°	Summer solstice sunrise
		Arcturus (rising)
		Pleiades (rising)
C	115°	Winter solstice sunrise
		Antares (rising)
D	150°	Canopus (rising)
E	192°	
F	245°	Winter solstice sunset
		Antares (setting)
G	288°	Regulus (setting)
H	349°	

line at close to a right angle. With our aerial photographs, we determined a point on the north-south base line that roughly corresponds to the spatial center of the whole complex. Realizing by now that the western enclosure's corner junction may have served as an "east-west pointer," we extended this line to that point on the north-south baseline. We posit an astronomical center, but the *heiau* must also be associated with terrestrial bearings of significance. With an accurate topographic map we plotted the bearing directions of Waipi'o Valley, Hawaii, 'Umi's birth place, and also the summits of the three surrounding high mountains transposing all these bearings onto an accurately produced base map. These were checked against an enlarged, vertical aerial photo before proceeding with the placement of our transit in situ to match the central point on the map. From this point, directions and scaling lengths were measured, including routine measurements of wall lengths, cairn widths, and so on. As a check on the precision on our north-south base line, we conducted a noon-shadow line experiment at the winter solstice. In this, the shadow of a pointer falls on the north-south line at local noon when the sun transits the meridian at Ahu a 'Umi.

We assigned letters to cairns starting with Cairn A east of north and working clockwise through the next seven cairns, B, C, D, E, F, G, and H. The widths of the cairns allow for approximate naked eye sightings of astronomical phenomena, assuming that astronomical observation was an intended purpose of Ahu a 'Umi's design. The results of winter solstice readings of the cairns from the center point are given in TABLE 1.

AHU A 'UMI AND THE TRADITION OF HEIAU CONSTRUCTION

We shall now look at Ahu a 'Umi from the standpoint of the tradition of *heiau* construction and use.

Hawaiian historian Samuel Kamakau points out that, in *heiau* construction, the foundation was laid down before enclosing walls were made:[11] "When the *kahua* (foundation) of the heiau was finished a stone wall was built around it, and seven terraces (anu'unu'u) made." Kamakau is talking about a terraced *heiau*, not one like Ahu a 'Umi, but it is true for both types that the design of the *heiau* was contemplated before it was laid out and the building of the walls was not attempted until the places for each of the components had been determined. Malo attests that the architect first exhibited the plans of the *heiau* on the ground to the high chief with an explanation of all its significant parts:

> "If the king, the priests and others agreed that it was best to build an entirely new luakini, the kahuna kuhi-kuhi pu'u-one was sent for. It was his function to exhibit a plan of the heiau to the king . . . the plan of which the kuhikuhi pu'u-one explained to the king; and if the king was pleased, he first made a sort of plan of the heiau on the ground and exhibited it to the king with an explanation of all its parts, so that he could see where the fence was to run, where the houses were to stand, and where was the place for the lananu'u-mamao with the idols."[12]

There are at least two categories of *heiaus*. One type is the Lono *heiau* raised to the god of peace and agriculture; the other is the Kū *heiau* for the god of war and human sacrifice. Structurally, the Kū type is usually built with a smaller companion enclosure called the Hale o Papa (House of Earth-Mother) nearby. The Lono type does not have the companion. Within the confines of a *heiau*, space is assigned to male and female. The male sides are usually north and east; the female, south and west.[12] From this description, it appears that Ahu a 'Umi *heiau* is patterned along the Kū type.

The literature reports that, in measuring distance and in enclosing space in a *heiau*, the builder used a stretching cord (*aha hele honua*, "earth-going rope") from a pivotal point to square corners and circumscribe area.[13] The limits of the *heiau* outside the walls of the Hale o Papa and main enclosure of a Kū *heiau* beyond the *papahola* borders were marked with crosses.[14] If the *aha hele honua* stretching cord was used to circumscribe the area of a rectangle, such as one of the sacred houses on the *kahua*, it seems likely that it was also used to determine the

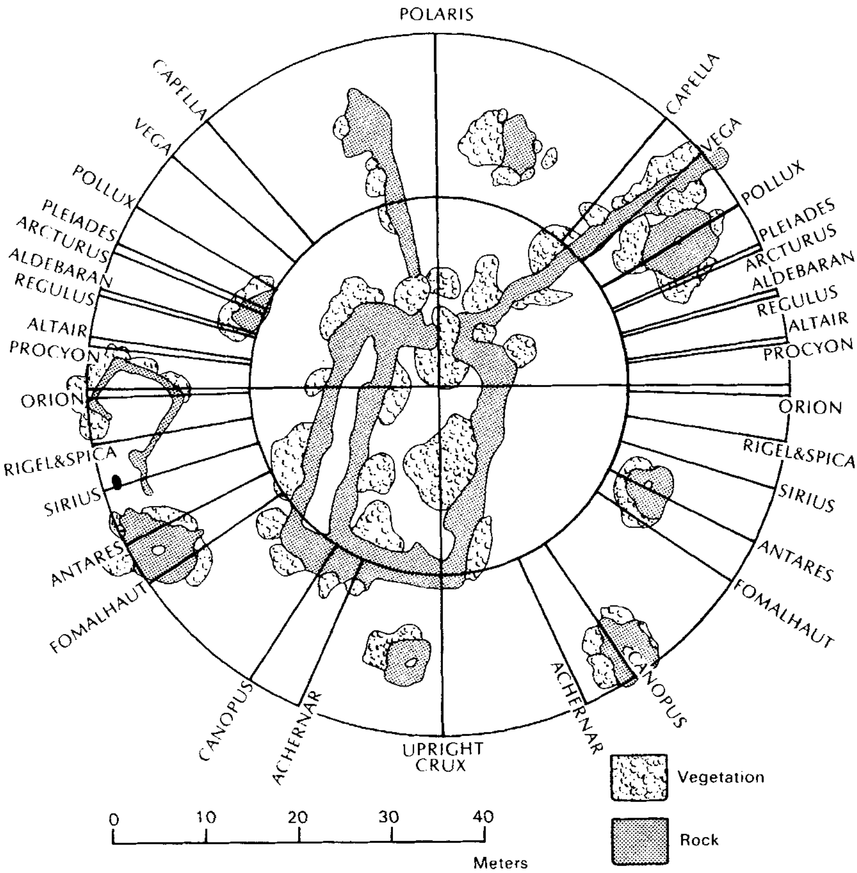


FIGURE 3. Star compass, A.D. 1500.

pivot point from the center to the *papahola* limits. Hawaiian *heiaus* are of circular as well as rectangular form.[15]

We posit that, once this spot was determined, the priest established his north-south base line by aligning the poles to Hōkūpa's (Polaris), 'Fixed-star,' and Newenewe, the upright Crux.[16] His east-west base line would then be established at the equinox, with Orion's belt (Na Kao) rising only one degree south of the point of equinoctial sunrise. This east-west line corresponds to the celestial equator, *ke alanui i ka piko o Wākea,* "the way to the navel of Wākea" (the universal Sky-Father).

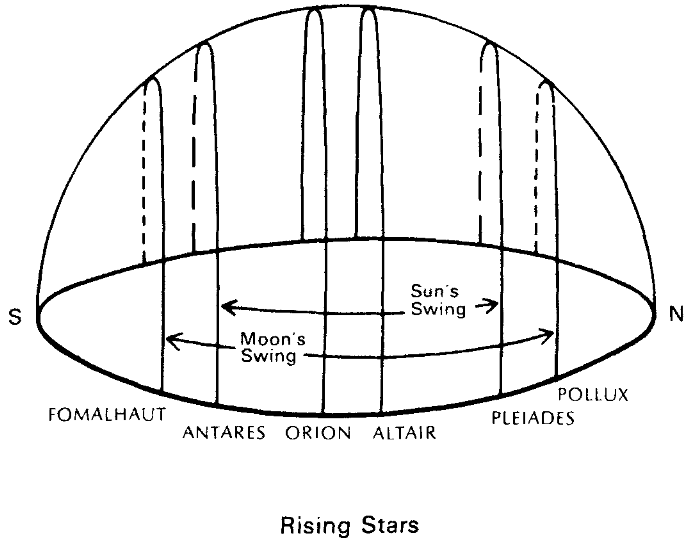


FIGURE 4. Hawaiian sky dome.

THE HAWAIIAN GOURD COMPASS-CALENDAR

Tradition also reports the existence of a so-called "gourd compass," (FIGURE 3). From the definition of this gourd, we can guess that it contains a representation of the cosmos that includes the northerly and southerly swing of the sun, the celestial equator, and the points of rising and setting navigation stars. Such a compass served as a register for the Hawaiian "tropical year of 360 days" (FIGURE 4).

The *ke alanui polohiwa a Kāne*, meaning the "black shining road of Kāne," and the *ke alanui polohiwa a Kanaloa*, meaning the "black shining road of Kanaloa," were represented by parallel lines that marked the northern and southern march of the sun. The annual motion of the sun, the northward and southward swing of the sun during the year, was described as *ke ala a ke ku'uku'u*, meaning the "pathway of the spider." It is that distance on the gourd compass between the two parallel lines. This served as a measure of time; that is, it represented 180 days, half the Hawaiian tropical year.

Thus, the gourd compass may be seen as (1) a directional guide and (2) a calendar. As a compass it provides azimuthal directions for the rising and setting of navigational stars; as a calendar it integrated the Hawaiian

tropical year with the altitudinal movements of stars across the night sky.[16] While this compass-calendar was designed to be set in a gourd, perhaps as a mnemonic device, it could also have been carried in the mind of the Hawaiian *kahuna kilo hōkū* (star-gazing priest).

The concept of the center of the earth is expressed in Hawaiian as *ka piko o ka honua,* "the navel of the earth," that of the horizon circle as *ke kukulu o ka honua,* or ambit of the circumscribed area, the "compass of the earth." Measuring with the cord was called *e ka'i i ka aha hele honua,* "to lead the earth-going cord." A circle measured by this cord would intersect lines extended toward the solstice sunrise and sunset points from a center. The line of a cord drawn or stretched between the solstice points on the circumference of the ambit represents the annual motion of the sun on the ecliptic, called the "pathway of the spider" (*ke ala a ke ku'uku'u*). This length would represent both distance and time, that is, a given distance on the ground requiring the passage of 180 sunrises or sunsets, or one-half the annual path along the ecliptic (tropical year with intercalation of about five days). A specific measured length of earth may then be identified with the measured time in the sky. From this arrangement the number of days from solstice point to solstice point could be expressed as a given distance marked on the ground or along the horizon. This length represents the "path of the spider."

THE PYTHAGOREAN TRIANGLE AND THE PATH OF THE SPIDER

A feature in some Hawaiian *heiaus* is a distinct ratio between the length and breadth of the foundation. We found that Ahu a 'Umi had a width of 17.4 meters and a length of 22.8 meters, which gives a diagonal of a right-angled triangle that accords with the proportions of the Pythagorean triangle (FIGURES 5 and 6). On this basis, we provide a theoretical representation of Ahu a 'Umi (FIGURE 7). This representation fits not only this *heiau* but other *heiaus* elsewhere (FIGURES 8 and 9). We believe that the Pythagorean ratio is one of the ratios used in the construction of *heiaus* in Hawaii.

At Ahu a 'Umi, we discovered that the distance between the extreme corner of the Hale o Papa enclosure and the central point, defined as the *piko* (navel), is related mathematically to the length of the diagonal of the main *enciente*, supporting the belief that our central point is close to the focal point for the whole complex. If we use the Hale o Papa distance as a radius and draw a circle centered on the pivot point, we would find

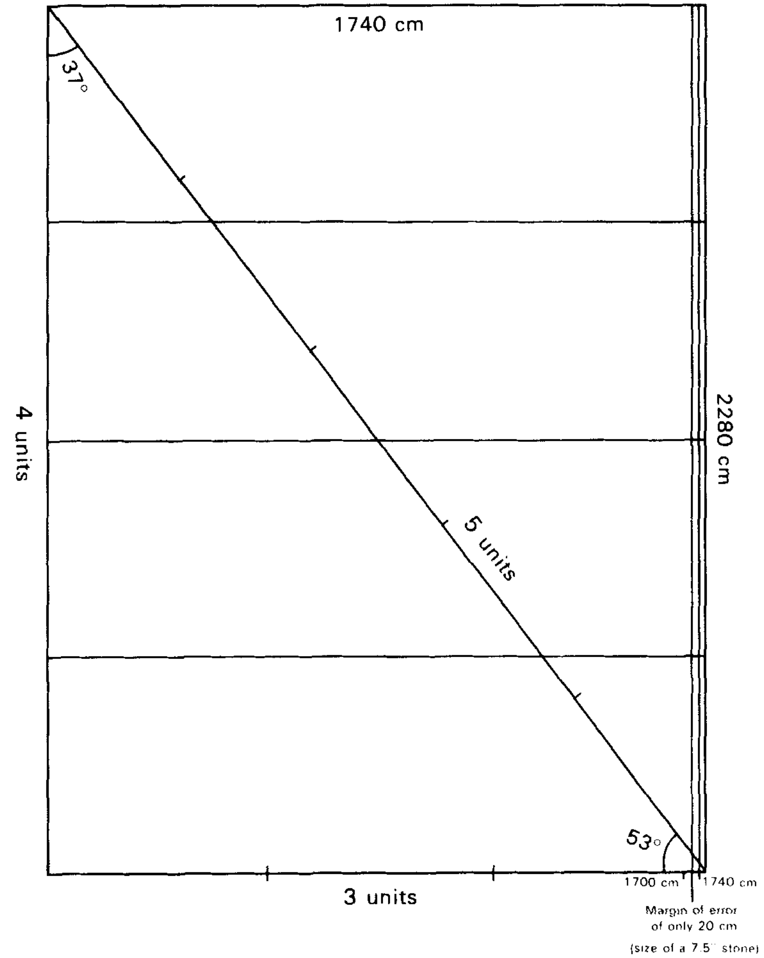


FIGURE 5. Kahua dimensions of the interior section of Amu a 'Umi based on field measurements.

that the straight line joining the solstice points on this circle would be the "path of the spider," representing 180 days of the Hawaiian tropical year (FIGURE 10).

We further discovered that the length of the "path of the spider" matches the diagonal length of the main *enceinte,* the five-unit side of the Pythagorean triangle.

The relationship between the radius from the Hale o Papa structure to

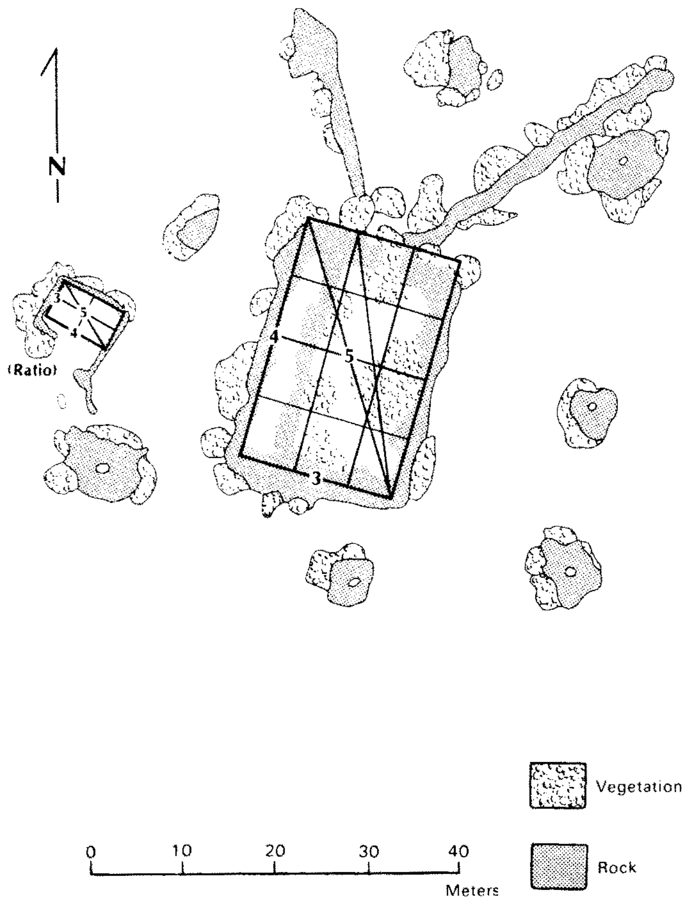
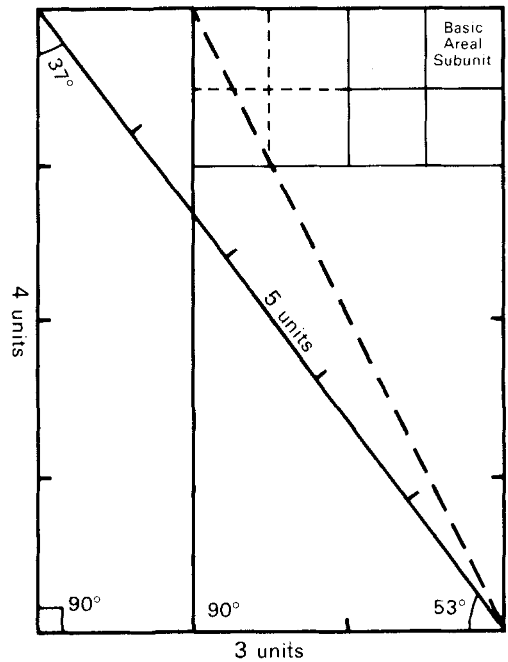


FIGURE 6. The outlined area is represented by a clearer geometric model on the reverse side.

the pivot point, the length of the main *enceinte*, and the ground length representing 180 days of the Hawaiian tropical year can be expressed mathematically.

At Ahu a 'Umi, if the radius of the circle of the earth is assigned a value of one, and the angle subtending the solstice points is θ, then the mathematical relationship can be expressed as:

$$2 \sin \theta = \text{the chord joining the solstice points on the circle}$$



The Pythagoras Theorem: "The square of the hypotenuse is equal to the sum of the squares of the other two sides."

$$(5 \text{ units})^2 = (4 \text{ units})^2 + (3 \text{ units})^2$$
$$25 = 16 + 9$$

FIGURE 7. A possible theoretical arrangement of Ahu a 'Umi Heiau.

Expressed in another way:

$$2 \sin \theta = \frac{\textit{ke ala a ke ku'uku'u}}{\text{radius of } \textit{ke kukulu o ka honua}}$$

$$2 \sin \theta = \frac{\text{the path of the spider}}{\text{radius of the compass of the earth}}$$

This relationship is trigonometric and important to the understanding of *heiau* construction. The diagonal length of the *heiau* is set by the length of the "path of the spider," which, in turn, is determined by the size of the "compass of the earth," which is set by the radius extending from the "navel of the earth" to the edge of the "house of Papa, earth-

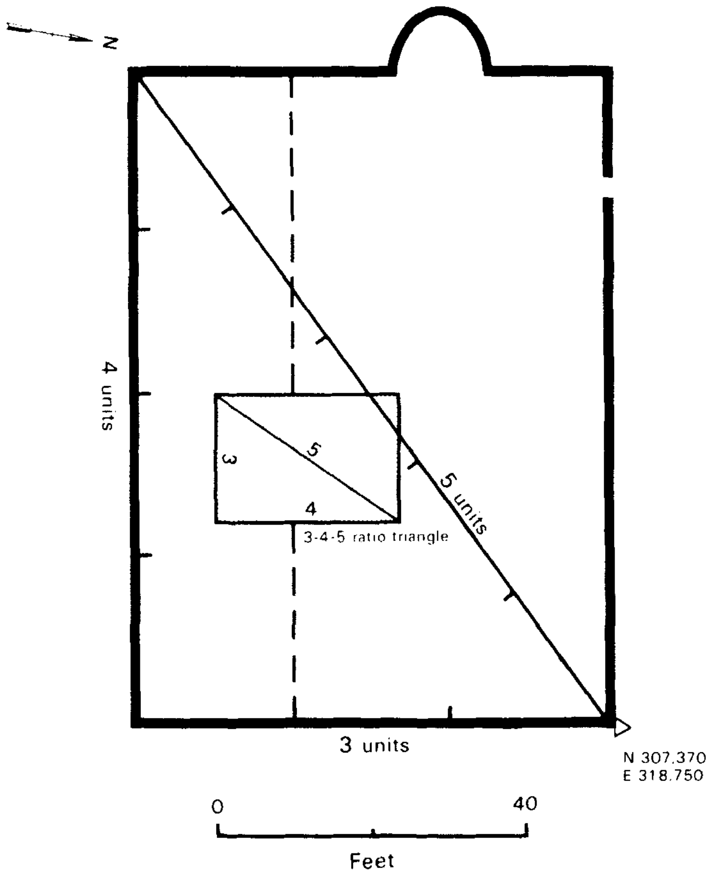


FIGURE 8. Kahua dimensions of a "house site" (*heiau*?), the proportions of which are similar to those of Ahu a 'Umi Heiau.

mother." These indigenous terms are concepts of dimension expressed in the symbolism of profane space made sacred by relating sky to earth, which is a rationalization of cosmology.

If the Pythagorean five-unit side is used as a measure, then the Hawaiian tropical half-year of 180 days may be partitioned into five single units of 36 days each on the diagonal of 'Umi's *heiau*:

3 units × 36 days = 108 days
4 units × 36 days = 144 days
5 units × 36 days = 180 days

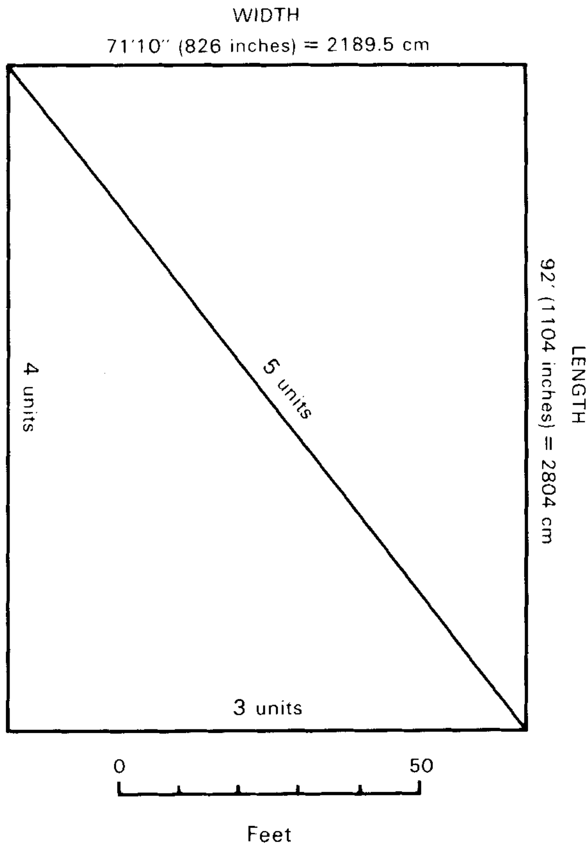


FIGURE 9. Kahua dimensions of Ahu a 'Umi Heiau based on the Wilkes map of 1840.

The squares (areas) of these sides would correspondingly be:

9 units × 36 days = 324 days
16 units × 36 days = 576 days
25 units × 36 days = 900 days

The sum total of these would be 1800 days, or 10 Hawaiian tropical half years, or 5 Hawaiian tropical years of 360 days.

Thus, symbolically, the *kahua* of the central *enciente* of 'Umi's *heiau* is represented by time. In the mind-set of the astronomer priest, area is equated with time, space with days.

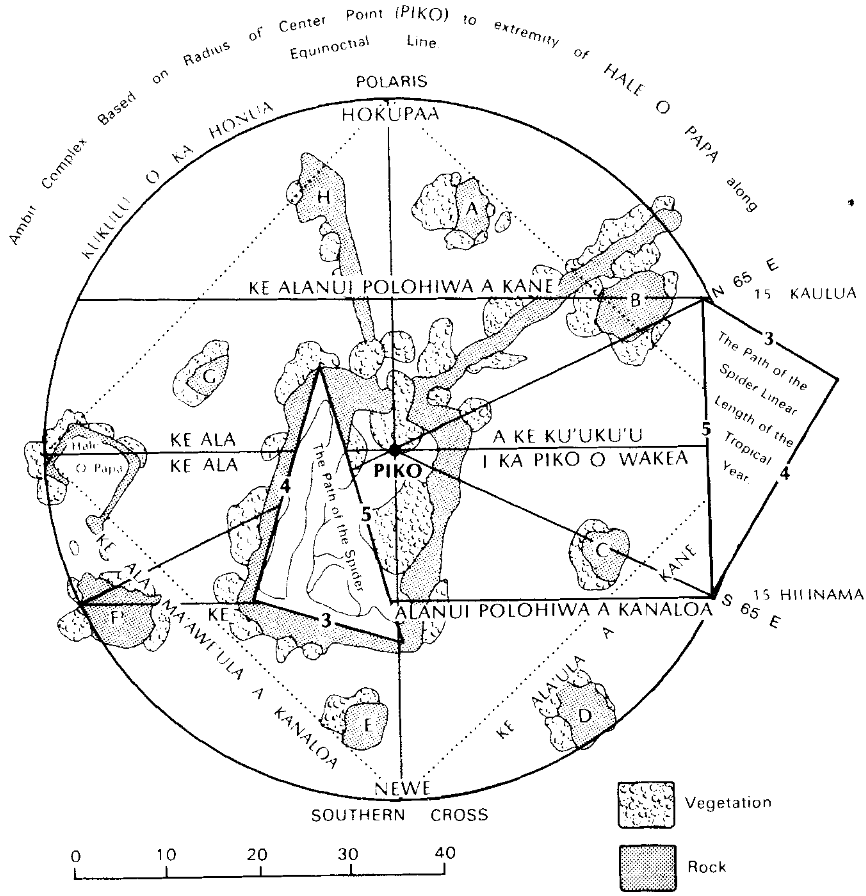


FIGURE 10. The path of the spider.

AHU A 'UMI HEIAU AS A DIRECTIONAL REGISTER

A particular feature of this *heiau* is that its main axis is not oriented towards Polaris, near true north, but tilted to east of north. This tilt is closely oriented to the azimuthal rising of Dubhe, the rim star of the Big Dipper (which is called, in Hawaiian, *Na Hiku*—the seven). The rising point of Dubhe accords with the direction of Waipi'o Valley, the birthplace of 'Umi. We suggest that this may be a reason for the tilt of the main *enceinte*, as this "Royal Star" can be viewed through the opening in-

to the main enclosure. If this is the case, and more study is needed, then the entrance is directionally and astronomically aligned to the positions of the Big Dipper around Polaris nightly and throughout the year.

There are other orientations that, we suggest, are significant. Cairns B and C on the sunrise side and Cairns E and G on the sunset side accommodate the most northerly and southerly extents of the moon's swing as well as those of its minimum nodes. From the pivot point, this most northerly extent of moonrise aligns with the summit of Mauna Kea. Cairn B in particular, the largest and the best existing *ahu*, appears to be a significant ritual platform for the observation of (1) the summer solstice rising sun, (2) the heliacal rise of the Pleiades, which is associated with the great *makahiki* season, and (3) the rise of Arcturus, the navigational zenith star of Hawaii. (FIGURE 11).

One is awed by the genius of the architect. He had to arrange the geometry of Ahu a 'Umi Heiau to accommodate significances in solar, lunar, stellar, and terrestrial orientations. We believe that he succeeded in this effort. Hōkūloa, the Morning Star, Venus, was the most prominent feature in the early morning sky on that winter solstice morning. The secret of Venus's role at Ahu a 'Umi escapes us. Perhaps only the *kahuna kilo* knew.

SUMMARY

This article is only a preliminary note to interested observers in ethnoastronomy and archeoastronomy that the geometry of the Ahu a 'Umi Heiau on the island of Hawaii is arranged so as to align, astronomically and directionally, with the moon, the sun, the stars, and an imposing mountain top, as well as the birthplace of the Hawaiian high chief for whom the *heiau* was constructed. This arrangement assumes meaning when placed in the context of the astronomical knowledge of the ancient Hawaiians embodied in the Hawaiian star compass-calendar and the ancient rituals associated with the cosmography of terrestrial and celestial space.

If the gourd-compass diagram of instruction by Keneakaho'owaha, considered in the light of this study of Ahu a 'Umi, may be given credence, then the results may reflect the inference of Makemson that

> there is ample evidence that the Polynesians visualized a zone of about 50° wide symmetrical about the celestial equator, and bounded on the north by a parallel of declination through the June solstice and the Pleiades and on

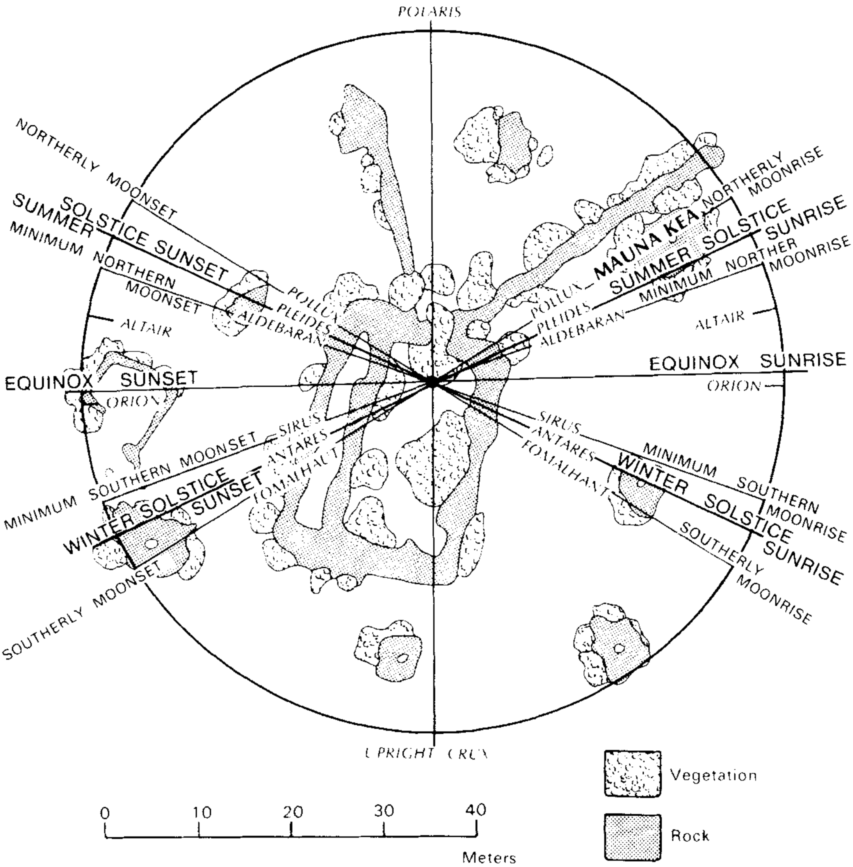


FIGURE 11. Solar-lunar-stellar associations.

the south by a corresponding parallel through the December solstice and Antares. Through this wide belt of sky moved the Sun, Moon, and planets. Within this zone were all the stars which were suspended in the zeniths of the islands of tropical Polynesia. In it were situated most of the stars used for guiding the canoes on ocean voyages. Outside it were the stars of space or "foreign" stars as previously described in a quotation from the Hawaiian scholar, Kamakau [i.e., Kanaeakaho'owaha].[17]

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Summary

Archaeoastronomy in the Tropics*

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THIS CONFERENCE on archaeoastronomy and ethanoastronomy of the tropics was organized under the principle that there exist *two* essentially different archaeoastronomies. One, the Megalithic archaeoastronomy of the high latitudes, records the carousel-like motions of the heavens around the observer: up, around, down. In this northern archaeoastronomy of the British Isles, and possibly the medicine wheels of North America, the obvious calendarial moments are related to motions along the horizon. The other is the archaeoastronomy of the tropics, where the motions are up, over, down, and under. When the sun can pass directly overhead, that moment takes on a prime calendrical significance, and while horizon markers may be present, they will tend to record events associated with the solar zenith passages.

So much for the hypothesis that has given the conference its rationale and framework. Has it been demonstrated? Has it successfully supplied the thematic glue to hold the conference together? In my opinion the answer is no! From the point of view of a central thesis, the conference was a shambles. There are hints that the ancient Mexican astronomers did take the zenith passages seriously, but there are equal indications that horizon astronomy unconnected with the sun was present. The zenith orientation of the Intihuatana, the so-called "hitching post of the Sun" at Machu Picchu, has been demolished by Dearborn and White, unless the stone pillar was heavily sheathed in gold to change its angles. We were well informed of the cosmology of the Barasana, the Desana, and the Bororo – a cosomology of looking up – but I was convinced neither that

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there is a well-defined fifth direction of up-down developed in their cosmic views nor that their primitive views of the sky are necessarily all that different from those the Plains Indians might have accepted or even those of the Paleolithic cave painters.

This is not to deny that the conference was a splendid success. It introduced me to a whole new world of ethnoastronomy, and to a whole new group of scholars not normally found in the astronomical circuits. In brief, the conference broadened my horizons.

Yet the problem in slicing ancient and primitive astronomy this particular way is that the sophisticated Maya are as different from the nonliterate Kogi as the Renaissance astronomers were from their ancient Egyptian counterparts. Could it not well be more enlightening to contrast the Maya with the Babylonians, or the Barasana with the Egyptians of the early second millennium B.C., rather than comparing the Barasana with the Maya? Let me indicate briefly where some of these parallels and interdisciplinary connections *outside the tropics* might be made.

The ethnoastronomers repeatedly mentioned the key role played by the Milky Way in the primitive cosmologies of the tropics. The richest part of the Milky Way rides high in the heavens here, undoubtedly the most striking feature of the night-time sky. Not only its brilliance, but its dark holes have been noticed by these observers. Just north of the Tropic of Cancer, in ancient Egypt, the Milky Way also played a fundamental role: according to the work of Virginia Lee Davis, largely unpublished, it was seen as the heavenly Nile and the path of the sun. It divided the sky into the land and the water, and the southern constellations such as Isis and Osiris were always depicted as riding in boats.

A second celestial marker cited repeatedly in the conference was the Pleiades. This asterism has a unique appearance in the sky and therefore, unlike the brighter first magnitude stars, it cannot be mistakenly identified. The Babylonians frequently cited it as *mul-mul,* literally "star-star," which designated its superlative standing among the more ordinary stars. The Pleiades' distinctiveness combines with its northerly position along the ecliptic to give it a special role in calendrical astronomy. Aveni has suggested that a pair of pecked crosses matching the grid orientation of Teotihuacan may be aligned with the setting of the Pleiades. Johanna Broda cited the passage from Padre Sahagun about the lighting of fires coincident with the midnight zenith passage of the Pleiades and the end of the 52-year round of the Mesoamerican calendar. Here, however, I must lodge an astronomical protest, for the 365-day Mesoamerican calendar cycles throughout the seasons in 1400 years just

as the ancient Egyptian calendar did, and hence would have presented the same problem of keeping the Pleiades in step that the Egyptians had in keeping the Sirius rising correlated with the Egyptian year.

This leads, parenthetically, to a more general criticism of several of the conference papers. There was frequent mention of star alignments but without any dates. Because of the apparent 26,000-year precessional cycle of the starry framework, horizon alignments of stars are valid for a finite time: precisely how long depends on the precision required. In many of the cases cited the alignment was so rough that the sight line could have been approximately valid for several centuries, but nevertheless dates should have been given explicitly. For example, nowadays the Pleiades have zenith passages over Durango; in A.D. 700 they passed directly over Teotihuacan, in A.D. 300 over Palenque, and in 200 B.C. over Copán.

I now turn to a third conference theme that connects beyond the astronomy of the tropics. Richard Townsend discussed the cosmic state as reflected in an architectural microcosm. And this reminded me of the siting of the Ring of Brogar on the Orkney Islands. Alexander Thom has claimed that this large stone ring is perhaps the leading Megalithic lunar observatory. On a gut level, it is difficult for me to be convinced that this peninsular site in the middle of the Orkney Mainland was chosen primarily for certain rather obscure lunar sightlines. But as the cosmos in miniature, the site could scarcely have been better chosen, combining the elements of earth, sky, and sea in a relatively flat and secure setting. In a way, this is much like the stone boats used in Micronesia for teaching navigation. Again, the challenge of representing the cosmos architecturally reappears in the multiple levels of interpretation of R. T. Zuidema's *ceque* lines at Cuzco.

Derek DeSolla Price, in a fascinating essay in the *Annali* of the History of Science Museum in Florence, has argued that most early instruments—astrolabes for example—represent attempts to place the cosmos in the palm of the hand, rather than devices for actually measuring celestial positions. The modern planetarium projector is perhaps the contemporary equivalent. I believe this is a promising insight to keep in mind in interpreting ancient sites either in or out of the tropics.

Finally, the conference gave us a wonderful richness of metaphor, something I think ought to be spotlighted explicitly. The complexity of symbolism transcends the specific case of the cosmos in architecture. There is the theme of weaving appearing in Cecilia Klein's analysis of the Mesoamerican cosmic center; transformed, it reappears phoenix-like in

the Inca quipu. Centuries later, in his *Astronomia nova*, Johannes Kepler pondered whether he should liken the paths of the planets to a ball of yarn. And the nodes of the moon's orbit, where eclipses can occur, translate in many other languages as "knots."

Or, to pick up another rich family of connections, there is the planet Venus, linked in its rhythmic motion to the Pleiades, found in the architecture of the Caracol at Chichén Itzá or in the Nunnery at Uxmal, and certainly, by the rather simple nature of its cycles, at the foundation both of Babylonian astronomical methods and of the Mayan codices. And this reminds me to note that I missed David Kelley and mention of his work at this conference. His recent paper in *Archaeoastronomy* (No. 2, 1980) describes how the motions of Venus and the other planets may be intricately woven into the naming of days and months in the Mayan calendar. The sheer complexity of his argument raises it beyond the ordinary bounds of ethnoastronomy, yet he suggests that at the base the scheme is an elaborate mnemonic device—but surely the sort of mnemonics that only a literate culture can indulge in.

This remark brings me full circle to my opening gambit: the papers were interesting, but the theme of the "tropics" can scarcely bind together contributions as diverse as a correlation of the Mayan calendar with the western calendar, and a discussion of the social behavior of the Colombian Indians. And yet we must admire the brillant attempt of Anthony Aveni to put this Humpty-Dumpty together again. I found him quite persuasive on the idea that in the tropics the motions are perceived as up and over (rather than up and around), and this is at least partially verified both in the ethnoastronomy and in the archaeoastronomy. A key idea concerns the 260-day cycle: fundamental in the motions of both Venus and Mars, it also works as the period between solar zenith passages for the principal band of Mayan cities. The pecked crosses of Mexico, with their combination of numerological and orientational properties, and the ceque lines of Cuzco reinforce these loose connectivities. Without being 100 percent convinced that the theme is strong enough to bind reports on astronomy at such variant levels of sophistication, I am nevertheless prepared to believe that there really are different ways of thinking about what the sky does, and that an important difference is the latitude of the observer.

The Tropical Zone: Land of Opportunity

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FEW HISTORIANS of astronomy have ventured into tropical zones. Those who have—to concentrate on the astronomical activities of the inhabitants of the subcontinent of India or the Middle East—have entirely avoided the southern hemisphere. This conference is witness to the fact that such hesitation before the Tropic of Cancer is, fortunately, not shared by all scholars. Anthropologists, archaeologists, astronomers, and historians of art have all obviously recognized the tropical zone as a fertile field for study and one that has long nourished the practice of astronomy.

My own privileged access to the papers delivered at this conference has allowed me a glimpse of what hesitant historians of astronomy are missing. In particular, I observe that they are missing both an opportunity to carefully assess the role of geography in the development of astronomy, and an opportunity to use the widest possible variety of scholarly tools to examine the relationships that can exist between developing science and developing society.

Let me consider these "missed opportunities" in the light of the papers presented at the conference.

THE ROLE OF GEOGRAPHY

The opportunity to assess the role of geography in the development of astronomy has been recognized most readily by the conference chairmen. Aveni, in his keynote address, stresses the value of comparing tropical and nontropical astronomies. Urton, in his major paper, emphasizes the importance of comparing, within the tropical zone, astronomies developed in coastal and mountainous environments.

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Comparisons of astronomies practiced within and outside of the tropical zone must, as Aveni has shown, inevitably focus upon the one astronomical event that has been used by astronomers at least since Claudius Ptolemy to distinguish these geographic areas; that is, solar zenith passage. One might expect this event, and, by association, the observer's zenith in general, to play a significant role in tropical astronomies and a less important role in nontropical astronomies. Scholarship heretofore reported by historians of astronomy confirms the latter hypothesis. The various papers given at this conference speak to the former hypothesis. Aveni reports evidence of zenith-oriented astronomy practiced by the people of ancient Java, by the Aztecs of Mexico, by the Zapotec occupants of ancient Monte Alban, by the ancient residents of Xochicalco, by the Cuzquenos of 15th century Peru, and by early Polynesian navigators.

Other speakers have developed this theme further. In her paper, Johanna Broda emphasizes calendrical clues to the significance of solar zenith passage. She points out that observations of this phenomenon offer the possibility to check the correspondence of the calendar and the solar year twice every year. She associates the vertical tubes discovered at Monte Alban and Xochicalco with such observations. Unfortunately, no eyewitness accounts are available to substantiate this certainly plausible interpretation of circumstantial evidence. As Broda points out, sixteenth century ethnohistorical sources from central Mexico do not reveal, by themselves, the importance of any solar event, much less zenith passage.

Two groups of Indians of Colombia described by Reichel-Dolmatoff are said to incorporate zenith events into their astronomy: the Desana by according zenith solar passage a key role in their origin myth and the Kogi by constructing temples that accomodate zenith observations. David Dearborn reports finding a window of the Torreon at Macchu Picchu with an alignment that could be used to herald the approach of zenith passage. R.T. Zuidema has reminded us that alignments between centrally located observations points in Cuzco and horizon markers emphasize the importance of both zenith and nadir solar passage. Gary Urton stresses the agricultural importance of knowledge of both zenith and nadir events. Clemency Coggins argues that one major axis of the Mesoamerican cosmos passed through the zenith and nadir points. Stephen Fabian points out that the Bororo of Brazil designated the zenith the center of the sky.

There appears to be ample evidence that tropical astronomies incorporated phenomena associated with the zenith. The premise that zenith

phenomena dictated the nature of the astronomy developed in the tropics and that the astronomy so dictated is peculiar to the tropics is, however, and, I think, will remain, difficult to establish. It is difficult to test such a premise with comparable ethnographic data from the temperate zone. Indigenous, nontechnical astronomy is rarely accessible outside the tropics. This very fact makes studies of tropical astronomy all the more valuable.

Rather than considering the effect on developing astronomies of different celestial phenomena, Gary Urton has recognized the value of considering the effects of topographic variation on the interpretation of the same celestial phenomena. He shows how coastal and highland cultures of Peru, although having different reasons for needing to interpret celestial events, may in fact emphasize the same celestial events. The event that heralds the beginning of a planting season in the highlands may mark the end of a coastal fishing season. It is those celestial events which have environmental significance that can provide clues to the stages of development of a given culture's astronomical thought. Astronomies can be characterized as either provincial or cosmopolitan, depending on the extent to which they incorporate observations that have no application to local activities. Urton wisely recognizes that transitional areas (midway between the coast and the highlands) hold the key to understanding the application of astronomical cycles to societal needs.

THE TROPICAL ZONE AS LABORATORY

The majority of contributors to this conference have recognized the tropical zone as a well-equipped laboratory in which the role of the interpretation of celestial phenomena in the development of society can be studied. They have considered this role as it is reflected in concepts of time and space. With respect to concepts of time—a particular preoccupation of ethnoastronomers—they have illuminated the observational basis of ritual calendars and even the celestial orientation of indigenous historiography. If considerations of the role of astronomy in society as it is reflected in concepts of space seem more numerous than other considerations, it may be because both ethnographers and archaeoastronomers undertake them. From my perspective, three particularly interesting themes emerge from the various spacial considerations reported at this conference. These involve the possibility of astronomical influence over the notion of the *center* of space, the *shape* of space, and the *orientation* of enclosed space.

Preoccupation with the concept of the center may not be limited to the

tropical zone, but it has been recognized as an important tropically based concept by a number of conference participants. At least one of them has associated the symbolism of the center with the celestial phenomenon of solar zenith passage.

Particularly interesting, if somewhat mystifying, insights into the way in which astronomical events might influence concepts of the shape of space emerge from various studies reported at this conference. Tukanoan preference for hexagonally shaped space appears to be at least partially influenced by an effort to duplicate a pattern of bright stars. The quadripartite concept of space associated with Inca, Maya, and Central Mexican cultures has been related by conference participants to at least two types of celestial events. The four parts of Inca space may be related to each of four seasonal constellations, but may also be related either to the four occurrences of zenith and nadir passage or to the four occurrences of solar and lunar zenith passage. It is solstitial rising and setting points that seem to lend definition to the quadripartite nature of Maya and central Mexican space.

Questions relating to the orientation of confined space, or architectural enclosures, are generally raised and answered by archaeoastronomers. The importance of astronomical influence on this concept has not gone unnoticed by conference participants. They have recognized, however, that this influence must be considered in the context of other potential influences, not the least of which must be the topographical setting of the oriented space. Questions of orientation inevitably lead to considerations of precision, as indeed they have at this conference. By considering the precision of Maya architecture, Aveni and Hartung have affirmed the presence of purposeful spatial orientation.

CONCLUSION

In my opening remarks, I pointed out that very few historians of astronomy had ventured into the tropical zone. In addition to the fact that there is no accounting for scholarly taste, I am reminded by the contributions to this conference that the real barrier to studies of tropical astronomy by historians of astronomy might in fact be the amount of hard work such studies entail. They may require long periods of living in remote sites and exhausting, transit-bearing climbs up literal mountains of data. Even library- or museum-based studies involve integration of what must appear to many to be an overwhelming variety of evidence: primary sources, the codices, which every day convey new information

as they become easier to read; thousands of woven or knotted strings; ethnographic sources that sometimes reveal tantalizingly little about indigenous astronomical activity; calendrical data that still cannot be connected to the modern calendar with complete certainty; iconographic data that invites but does not easily yield to interpretation; and published architectural data subject to artistic license. Is it any wonder that historians of astronomy prefer temperate topics?

All the more reason to encourage scholars who welcome the challenge. This conference has revealed any number of studies that are still to be undertaken. These include—but are by no means limited to—considerations of the role, if any, of the nadir in northern tropical astronomy, comprehensive consideration of the role of the Pleiades in astronomies developed by nontechnical cultures, considerations of the quipu connection and, especially, efforts to answer the many interesting questions raised by Johanna Broda's paper identifying astronomy as a social coordinator.

Archaeoastronomy, Ethnoastronomy, and the History of Science

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THE CONFERENCE papers have displayed, above all, the richness of the astronomical and cosmological knowledge of the peoples of tropical America. One theme running through the entire conference has been the notion that these astronomies formed integrated wholes connected to the environmental, social, religious, and personal aspects of life. Many of the papers suggest that this is an anomalous characteristic of these astronomies, for real science, and particularly astronomy, engages in an objective study of the world aimed at accurate predictions and has few relationships to its cultural environment.

But, of course, this stereotyped picture of science is no longer accepted by most historians and philosophers of science, nor by those anthropologists studying the relationships between traditional thought and modern science. This being the case, I thought it might be wise for me, as the third historian of science to deal with these papers, to propose some general insights from recent studies of the nature of science, and see what they suggest for the twin disciplines of archaeoastronomy and ethnoastronomy.

Since the early part of this century, anthropologists have been attempting to come to grips with the nature of the traditional thought systems of nonliterate peoples. In this exercise, an extensive body of literature has emerged that seeks to define the differences and similarities between traditional thought and modern scientific thought. Historians and philosophers of science have, similarly, been attempting to define the characteristics of scientific activity. Again, many of their activities

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seek to draw a line of demarcation between scientific and nonscientific thought, based either on the methods employed or on the historical fact of the progressive nature of science. At present, however, there are no generally accepted criteria for demarcation.

This seems quite fortunate, for the papers presented here seem to demand an entirely different perspective. If we are to find any unity in traditional astronomies, it seems useful to ask how these astronomies relate to other scientific enterprises.

Early anthropological writers, following Lucien Lévy-Bruhl, tended to describe primitive man as imprisoned in a prelogical mentality, unable to separate himself from a personal encounter with nature.[1] Although most anthropologists now reject this notion, I might note that, until recently, it has been very influential among historians of Near Eastern thought, including historians of Greek science.[2] This suggests that both sides have much to gain by bridging the gap between history and philosophy of science on the one hand, and ethnoastronomy, archaeoastronomy, and anthropology on the other.

A key element of this concept of prelogical primitive mentalities has been that the natives' use of mystical, supersensible entities hindered their objective perception and comprehension of nature. Yet similar comments might be made about modern science. Throughout the history of science, supersensible entities such as epicycles, impetus, and uniformly flowing time have both contributed to the scientist's understanding of nature and hindered radical transformations of that understanding. Furthermore, theoretical constructs not only play a role in scientific explanations, but guide scientific observations as well.[3]

Such observations presuppose both a classification of the observed entities and a theoretical reference frame with which the observations may be compared and which lends certain phenomena their significance. Thus when a modern astronomer sees one star moving among all the other stars, he immediately sees that it is a planet. If he considers its motion further, he would watch how the planet moves along a geometrically defined plane, the ecliptic, observe that the planet's motion reverses itself because of its motion relative to the earth, and that the planet shines more brightly as it nears the point in its orbit where it is closest to the earth. The number of concepts in this description that are derived from theories of planetary motion suggests the extent to which the observations of the modern astronomer, like those of the Hopi Sun Priest who

watches the sun rise at its house on the winter solstice, are conditioned by the theory in which he is enmeshed.

Historians such as Thomas Kuhn have argued that such theoretical presuppositions actually restrict the scientists' perceptions of the phenomena and consequently their theoretical alternatives.[4,5] But, we might inquire, are modern scientists really constrained to maintain the theoretical presuppositions generally accepted by their contemporaries? The philosopher Karl Popper has argued that openness to alternatives is a defining characteristic of a scientist—and that insofar as one is not open to alternatives, one is not acting like a scientist.[6,7]

Among anthropologists, Robin Horton follows Kuhn part way in maintaining that scientists will first attribute anomalies to experimental failure such as "dirty apparatus or mistaken meter-reading—rather like the [Azande] oracle operator!" Nevertheless, he insists with Popper and against Kuhn that the questioning "spirit behind the scientist's actions is very different" from the diviner's. According to Horton, the scientist is always ready to abandon the present theory on the basis of conflicting observations.[8]

Ernest Gellner has pointed out Horton's inconsistency in praising Kuhn, while ignoring the principal thrust of Kuhn's position, that is, that scientists are also dogmatic and that dogmatism is an essential element of scientific research. Gellner maintains that the difference between closed and open mentalities, at least on an individual level, is not valid as a distinction between traditional and modern thought because many moderns are closed to alternate world views and some traditional thinkers are open to such alternatives.[9]

Barry Barnes observes, however, that the question is not appropriately determined by the actions of individuals, but by the social institutions through which scientific and traditional communities respond to observed anomalies. His chief consideration is that, because scientific concepts are so esoteric, they do not greatly influence the larger community, and so are more open to change.[10] Gellner agrees on this last point, observing that crucial elements are more widely dispersed in traditional thought systems, while modern scientific concepts do not, at the same time, delineate a moral or social order.[9]

It appears, however, that Gellner and Barnes exaggerate the gulf separating science from its social, moral, and cultural environment. A number of historical examples can be used to illustrate the close connections between scientific concepts and other elements of society. Those familiar with medieval astronomy should be aware of the thematic iden-

tity underlying the Aristotelian/Ptolemaic cosmology, with its hierarchical ordering of the planets and the descent of motive power from the periphery; the medieval church, with its hierarchical structure providing the channel of grace from God; and the idealized feudal political structure, with its hierarchical descent of authority from the divinely anointed emperor. Lest a medieval model seem inappropriate, consider the early modern period with its planets operating through an interplay of forces, its economics of competing individuals, its politics of a separation of powers, and its religion of individual salvation. Another example is the nineteenth century, with Romantic poetry and art, the anti-mechanism and anti-materialism of *naturphilosophie*, the emergence of energy as a physical entity on a par with matter, and the development of field theories of electricity and magnetism that moved away from simple mechanical models of causation.[11,12,13]

It seems, then, that the esoteric nature of scientific concepts does not provide a sharp line separating science and traditional thought, since, to some extent, modern science also shares elements with the other aspects of the culture in which it develops. But Gerald Holton, who has done much to point out the extension of science into other cultural areas, has also suggested a model that may be useful for understanding the relationships between science and other elements of culture. As a historian of modern physics, Holton expresses his model in geometrical terms.[14,15]

Holton notes that most discussions of science tend to focus on two aspects of science that separate it from other activities: empirical statements, which deal with those phenomena which scientists observe, and analytic statements, which deal with the logical and mathematical relationships between elements of a scientific system. These two aspects of science have not only attracted philosophers of science, but also those students of traditional thought who seek to emphasize its scientific content. When Lévy-Bruhl asserted that natives operate in a prelogical mode of thought, and his critics responded that natives, although they maintain different premises than moderns, do reason logically within those premises, they were discussing the analytic dimension of traditional thought. Similarly, when ethnoastronomers note the careful and detailed observations of natural phenomena that take place in traditional cultures, they are exploring the empirical dimension of traditional thought.

Holton suggests that we consider the analytic and empirical dimensions of a system of thought as defining a plane that defines science as it appears in textbooks and journal articles, as it is taught in the schools, and as it is studied by philosophers. The historian and the anthropolo-

gist, however, must deal with a third dimension of science, a "dimension of fundamental presuppositions, notions, terms, methodological judgements and decisions—in short of themata or themes."[14] By assigning themata to a separate dimension, Holton indicates their independence both of observational data and rational analysis. But even more important, from our point of view, is the fact that themata extend from the realm of science into other areas of culture. Hence, the theme of hierarchy was dominant in the middle ages, that of atomicity in the seventeenth and eighteenth centuries, and that of continuity in the nineteenth.

Such considerations make it clear that we cannot study systems of scientific ideas merely along their empirical and analytic dimensions; we must also consider the thematic dimension as one of the means through which science interacts with its cultural environment. In studying these themata, we are not studying something unique to traditional systems of thought. Of course, since these three dimensions differ fundamentally, we should expect different methods to emerge for the study of each dimension.

The diversity of methods is reflected in the papers presented at this conference, and I would now like to use Holton's three-dimensional model to examine a few of these presentations.

Beginning with those topics which are strictly in the empirical dimension, we find alignment studies such as those of Aveni and Hartung among the Maya ruins, Dearborn and White at Machu Picchu, and Zuidema at Cuzco. Treating them strictly as empirical data, the question of precision, applicable to all such data, can be brought into play. Aveni and Hartung clearly illustrate the kind of precision that we can expect from the Maya. The Maya could regularly align structures to an accuracy of 15′, so we should expect similar precision from their astronomy. The implication, of course, is that if we find naked eye alignments with less than this precision, we should seek an explanation of the anomaly.

The studies of Dearborn and White and of Zuidema raise other problems. How much are we to trust merely archaeological data when there is no further ethnographical or historical evidence to lend support to quantitative indications of precision? In this regard, Zuidema's use of documents to provide a historic context supports his discussion of Cuzco. Zuidema's study, however, while drawing on a large body of ethnohistorical data indicating that observations were made, does not always

make it clear how accurate the alignments are, or even the extent to which the alignments are reconstructions from historical documents, and the extent to which they are corroborated by archaeological evidence.

Another element in the empirical dimension concerns the identification of constellation and star names. Reichel-Dolmatoff among the Colombian tribes, Hugh-Jones among the Barasana, Fabian among the Bororo, and both Urton and Zuidema in Peru have made major contributions in this area. Here again, the nature of the empirical dimension invites objective identifications of stars and constellations. But beyond the mere identification of constellations, the existence of similar names suggests the existence of connections between astronomical systems.

A further important aspect of constellation names is that components of the names sometimes project beyond the merely empirical dimension into the analytic. When the Barasana name a constellation "caterpillar jaguar", they implicitly make a statement relating that constellation to the time of year when caterpillars are abundant. Connections like this are exemplified by the many instances of practical calendars that connect astronomical observations both to observations of the seasonal changes concerned with crops and to the concomitant rituals. Here again, it is possible to employ objective precision in studying both the empirical and analytic dimensions of these calendric systems.

Urton has reconstructed, with precision, the relationships of the astronomically based calendar in the villages of coastal Peru to the agricultural and marine environment, extending this to ethnographically dated festivals concerned with these factors. Broda has suggested similar connections among the Maya, even making the intriguing suggestion that the Maya may have had a true solar calendar among their calendric apparatus. Such a revision of the analytic dimension of Maya astronomy would truly revolutionize our understanding of the entire nature of Mesoamerican astronomy and of its connections to the astronomies of the greater Southwest. Returning to Peru, Zuidema has proposed a complex analytic structure used by the Inca of Cuzco. Here the evidence is not all in, and I look forward to further developments.

In all such attempts to reconstruct the analytic dimension of another culture's astronomy, we must take care that the analysis we are presenting belongs to the culture we are studying, and not to the student of the culture. The most important means of ensuring this is a careful presentation of the evidence and a rigourous separation of our analysis of the evidence from the evidence itself. Only then can our analyses be subjected to the rigorous criticism that ensures their validity.

This same warning applies, even more strongly, to the thematic dimension. Since themata are less precise than empirical and analytic systems, we are more open to self-deception when we study them. When Reichel-Dolmatoff speaks of the thema of duality extending into a left brain/right brain duality that plays an important role in Desana shamanic thought, I confess to extreme skepticism. The appearance of the brain as the organ of thought was a surprise, since that took some time to become established in Western Europe. The left brain/right brain duality sounds so modern that I wonder how much the Desana have had to do with readers of *Psychology Today*. If Desana culture has such an important place for drug-induced trances, the influence of such outsiders among the Desana cannot be ruled out, and seems to me the most economical hypothesis.

In a more positive vein, themata act in such a multitude of ways in societies that we can gain insights into an astronomical system from social structure, religious doctrines, and other areas of thought. Thus, the theme of duality, both in an above/below sense and and an axial (commonly east/west) sense, seems to operate in astronomy, in the ordering of villages, in the building of houses, and in the overall *cosmovisión* of many of the cultures studied. The wide dispersion of this thema among many different cultures suggests another role for thematic analysis; shared themes may be used, like common star names, to draw connections between astronomical systems. Of course, since themata are more general, the connections will probably be more general, and more speculative as well.

Considering the influence of themata on social organization, as well as on cosmology, it is significant that the more hierarchically organized Mesoamerican societies studied by Klein should also have a more hierarchical cosmos. The widespread theme of duality, separating the Above and the Below, has been modified to an alternative theme of hierarchy. How does this change relate to the social development of the more advanced societies?

Broda and, to some extent, Klein have suggested that certain aspects of Mexican astronomy and symbolism were consciously designed to reinforce the governmental structure. Broda asks, "why did this endeavour [the prediction of natural phenomena] transform itself at a certain point into myth, ritual, and ideology?" And, further, she hypothesizes that, "parallel to these sociopolitical processes [the rise of class society and the formation of the state], religion acquired a new function within class society. By means of this function the new power structures, based on

new relations of production, became 'mystified' in their true content. It was the purpose of this mystification to make the social relations appear to be just. . . . The foundation of the power of these priest-rulers resided precisely in the combination of their monopoly of astronomical observation and its application to the agricultural cycles; thus, they simultaneously controlled important aspects of social, economic, and political life."

There seem to be several elements in this argument: one deals with the assertion that the ruling class employed religious astronomy to justify their position, another with the assertion that the astronomical system was consistent with the structure of the state. I have no serious problems with either of these. However, the suggestion that this coherence was the result of a conscious integration of scientific observation, social organization, and mythical thinking seems, in the light of our studies of other cultures, to have the question backwards.

Again, the historian's experience may shed some light on my discussion. In 1939 the historian of Greek science Benjamin Farrington argued that Platonic science was part of an oligarchic program to reimpose a popular religious cult, while establishing a separate philosophical cult, both of which justified the existence of an exploitative ruling class.[16] In this view, Plato's denigration of physical reality in favor of the world of forms was a direct and conscious replication of the oligarchs' denigration of the working class in favor of the ruling elite.

Yet, as the thematic analysis of materials presented here suggests, there is a widespread tendency for scientific, religious, social, and political systems to adopt common cultural themata. The current opinion among most historians of Greek science is not that we need to explain why Greek philosophy reflects the patterns of Greek society; rather, that we need to explain why, for a time, Greek philosophers came to consider alternative, nontraditional, models of reality.[17] Stated this way, their question reflects anthropological insights into the integrated nature and consequent stability of traditional systems of thought.

Perhaps I can best end my discussion by quoting a recent editorial on the nature of the study of modern science by Arnold Thackray, the editor of the History of Science Society's journal, *Isis*. "Historians increasingly see all ideas—great and small, trivial and profound, scientific and artistic—as deeply imbedded in and shaped by the contexts of their creation, acceptance, diffusion, and use."[18] In sum, archaeoastronomers and ethnoastronomers are not alone in finding science closely wedded to its social context. For this reason, the insights derived from the study of

modern science can provide valuable conceptual guidance to those seeking to understand the science of nonliterate peoples.

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Culture Confronts Nature in the Dialectical World of the Tropics

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AVENI AND URTON are to be congratulated for organizing a conference that, for the first time, has brought together scholars from various disciplines to discuss the ethnoastronomy and archaeoastronomy of the American tropics. We have had to converse across disciplinary boundaries and I hope that the endeavor has clarified some of the concepts, methods, and perspectives of the different specialities represented.

As an anthropologist, I would like to suggest that the tropics provide a perceptual environment that promotes and enhances a particular 'science of the concrete,'[1] whereby perceived order in the environment is the basis for systems of classifications, epistemological structures, and cosmologies. In the American tropics, the science of the concrete takes on a particular character that results in epistemologies founded in what I will call dialectical, reversible dualism.

The native philosophers of the indigenous societies under discussion engage in the study of the nature and limits of knowledge. Their epistemological reflections are embedded in religious and ritual practices. Moreover, the native philosophers, who are usually shamans or astronomer-priests, use methods and metaphorical language that are unfamiliar to us. More importantly, the logic that underlies these systems of knowledge is dialectical rather than rationalistic. As Roy Wagner has pointed out in *The Invention of Culture*, the anthropological definition of the concept of dialectic refers to

> a tension or dialogue-like alternation between two conceptions or viewpoints that are simultaneously contradictory and supportive of each other.

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> As a way of thinking, a dialectic operates by exploiting contradictions against a common ground of similarity, rather than by appealing to consistency against a common ground of differences, after the fashion of rationalistic or 'linear' logic.[2]

Examples may help to clarify the two types of logic. In Western science, taxonomies and typologies employ the principle of similarity against a common ground of differences. The underlying assumption of rationalistic logic is linear causality. In sharp contrast, dialectical logic focuses upon simultaneous interdependence and contradiction. Linear causality is not assumed. For example, the most widespread dialectical concept in the American tropics is the *Axis Mundi*. While the cultural contents differ, the necessary tension is maintained between the opposed elements of the upperworld and the underworld. The interdependence is such that one cannot be defined without reference to the other.

By reversible dualism, I mean a logical process whereby the definition of one of the polar opposites must be derived from the view or position of the other. For example, the structure of the relationship between the polar opposites of the *Axis Mundi* necessarily means that one, the upperworld, must be defined by viewing it from the underworld. This principle of reversible dualism applies more generally, and I argue that astronomical phenomena in the American tropics are perceived as dual, dialectical pairs. One is necessarily the vantage point for the cultural definition of the other and vice versa. Therefore, time is perceived as a dialectical tension between two interdependent, but contradictory, elements. In part, this is due to the structural relationships that pertain between solar zenith and nadir phenomena and significant seasonal changes in weather, fauna, and flora. In turn, observable celestial periodicities—such as the phases and positions of the moon and the paths of various constellations—are sought that fit the epistemological structures that explain seasonal changes. For example, the path of the Pleiades is important everywhere in the American tropics for announcing seasonal changes. However, because the predictable appearance and disappearance of the constellation occurs with different periods throughout the American tropics, the significance differs from culture to culture. If I am correct about the structure of epistemologies in the American tropics, the Pleiades should always be opposed to some other celestial body in a dialectical, reversible relationship.

I shall discuss the structural similarities of the various native cosmologies as well as the culture-specific differences that have come to light in this conference. But first, I would like to make an observation

about the nature of the science of the concrete. Awareness of the regularity and structure of various naturally occurring periodicities provide the schemata[3] for verifying epistemologies in every culture. I suggest, however, that the structural peculiarities of the observable periodicities in the tropics result in a number of shared epistemological features.

Most significant is the fact that, in the tropics, celestial bodies move on straight tracks, rather than around a fixed point in the sky (the north and south celestial poles).[4] The perceptual consequence of this phenomenon is that the sky is divided into two halves. Moreover, as Urton has explained, the point of observational orientation is the movement of celestial bodies in relation to the observer's own fixed locality, rather than a fixed celestial pole.[5] Aveni has shown that all an observer needs are simple devices, such as crossed sticks directed to the horizon or

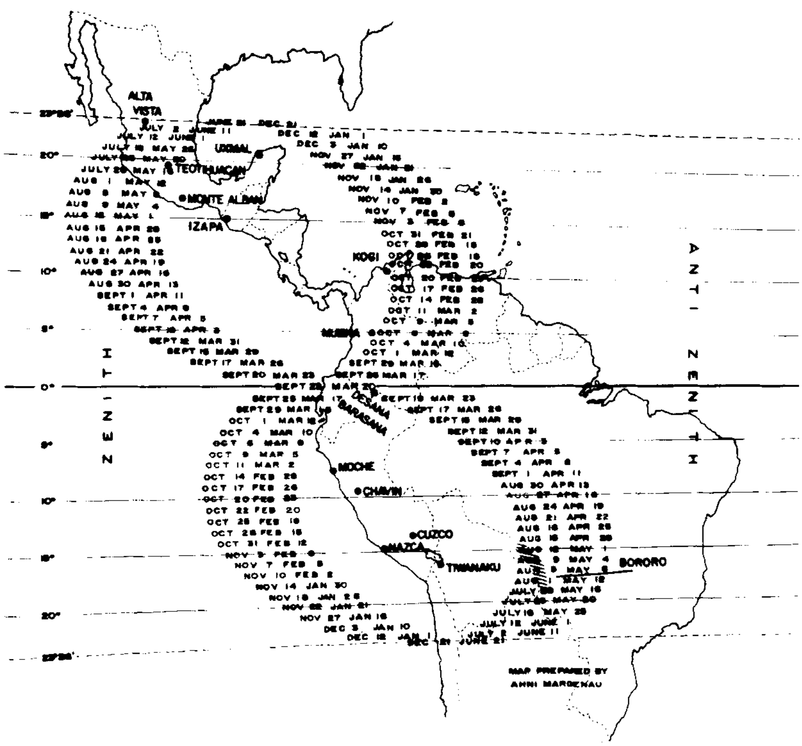

FIGURE 1. Zenith and nadir (antizenith) dates taken from the American Ephemeris and Nautical Almanac for 1980, correct for other years ± 2 days.

sighting tubes and gnomons oriented to the zenith, to make accurate astronomical and calendrical calculations and predict the approach of the solstices, the equinoxes, the cycles of Venus, and the zenith passages of the sun.[6]

Observed astronomical phenomena in tropical America play a large role in the development of epistemological structures. Specifically, the vertical orientation to the sky of an observer who is the fixed center around which celestial bodies move promotes epistemologies that have dual, symmetric, and reversible structures similar to those found in spatiotemporal structures of the native astronomy. In order to delineate a few of the similarities of the structures of space, time, and cosmologies, I will begin with an examination of zenith and nadir solar phenomena. In FIGURE 1, I have attempted to depict the symmetry and reversibility of zenith and nadir solar passage dates by drawing them in the shape of a figure eight. The zenith dates for each latitude are on the left; the nadir dates are on the right. Note that for each latitude, there are two zenith dates and two nadir dates, except at the lines of the tropics and at the equator. Zenith and nadir converge with the equinox dates at the equator. They diverge as one moves north and south until zenith passage of the sun coincides with the June solstice at the Tropic of Cancer (23° 26′) in the north, and with the December solstice at the Tropic of Capricorn (23° 26′) in the south. The relationship is reversed for the nadir dates. Moreover, if you trace the zenith passage dates from north to south, you will find that the dates for the nadir are the same (plus or minus two days) for the same latitudes, moving in the opposite direction from south to north. Consequently, the spatiotemporal relationships of the annual passage of the sun are like two interlaced cords, to borrow Klein's Mesoamerican metaphor for the structure of the cosmos. In studying the articulation between cosmologies and native astronomies in the American tropics, we find that culture confronts nature in an attempt to apprehend the dynamic relationship between time and space shown by the zenith and nadir passages.

In reviewing the data presented at this conference, I find three common principles of organization in the structures of tropical American cosmologies. I find, however, one significant difference. All four principles reflect the dynamic relationship between time and space in the tropics. The shared organizational principles are as follows: (1) The celestial paths of the sun, moon, and stars are conceived of as cosmic forces whose multiple interactions are responsible for transitions of time, climate, the agricultural cycle, and states of human existence. A cor-

ollary of this is that the major metaphors for cosmic order and disorder are based on principles of movement, of transition, and of reversibility, rather than on metaphors of static equilibrium, (2) these dynamic principles, based on observations of interacting cosmic forces, are replicated onto space in settlement plans and architectural and ritual space, as if the built environment of social space were a mirror reflection of the dialectical elements in the heavens, (3) finally, the most prevalent cosmological principle in the American tropics is the *Axis Mundi*, accompanied by what I will call a circulatory cosmology. The *Axis Mundi* is a world axis around which cosmological and celestial forces circulate. It is expressed metaphorically as a world tree, cosmic mountain, or a pyramid encircled or encompassed by a river, gut, an umbilical cord, or woven fabric. This vertical axis and its circulatory cosmic flow form two opposing dynamic principles, which maintain the dialectical tension essential to cosmic order.

The major difference I find is that between the structure of Barasana and Desana cosmologies and that of the cultures to the north and south. The Barasana and the Desana are located near the equator. According to Hugh-Jones and Reichel-Dolmatoff, neither place any importance on horizon observation of the annual movement of the sun. Nor do they make use of heliacal risings and settings to fix events in a calendar. They do, however, observe the zenith passage of the sun, which occurs during the equinoxes, and the annual paths of various constellations. The Pleiades, Scorpio, and Orion are among the important constellations observed as indicators of the changing seasons. Reichel-Dolmatoff makes a point that is true, I think, for both of these equatorial cultures: they are concerned with the diagnosis of the present state of affairs in the universe, not with a prognosis for the future. I would like to suggest that, at the equator, time and space conspire to give the observer the impression of being stationary at the center of the *Axis Mundi*, around which the universe circulates (see Hugh-Jones' excellent description of the structure of the Old and New Path of the Milky Way for details). Additionally, the dual rainy and dry seasons and the absence of a calendar based on tracking the annual movements of the sun on the horizon may intensify the perception that one is living at the center of present time and space. Consequently, the science of the concrete for cultures at the equator should be directed toward knowledge of the variations of the flora and fauna in their environments rather than precise astronomy and prediction of future events. Reichel-Dolmatoff mentions that the Muiska and the Kogi have more complex astronomical systems than do the Desana. Whether they also have a precise calendar is not clear. Fabian

hypothesizes that the Bororo have a complex system of observations and probably a precise calendar. These three cultures are far from the equator and would provide evidence concerning the relationship between the constraints of perceptual realities and the development of epistemologies.

As one moves farther and farther north or south away from the equator, the apparent annual movement of the rising and setting of the sun on the horizon becomes greater.[7] Moreover, the dates of zenith and nadir passages of the sun diverge until, at latitudes 15° north and south, the four zenith and nadir dates divide the year into more or less equal segments. Coggins argues that, at Izapa, 15° north, the zenith passages of the sun define the 260-day ritual calendar. Broda gives an excellent summary of current research on this question for Mesoamerica. Aveni and Urton suggest that zenith and nadir may be important for astronomical alignments and geometric forms among the lines of Nazca.[8] Zuidema argues that, at Tiwanaku, 16° 33′ degrees south, zenith and nadir passages divide the year into more or less equal segments[9] — an observation he believes to have been important to cultural developments in the Andes.[10] The site of Alta Vista, located at the Tropic of Cancer, provides sound evidence that the ancient astronomers of the American tropics were aware of the regularity and structure of zenith phenomena. In discussing the location and orientation of this site, Aveni states that the astronomers seemed to have been seeking the actual place where the sun turns around on its northern migration and begins its journey to its southern turn around position.[11] During the two solstices, the sun slows down in its march along the horizon as it approaches its northern and southern extremes. Aveni notes that "the sun will stand perched in the zenith at noon on the longest day, the first day of summer. A shadowless moment occurs as the sun arcs over the zenith and returns to its southern realm."[12] This annual journey of the sun is calculated by watching sunrise and sunset positions on the horizons — hence, horizon astronomy, a name that Aveni has coined.

Aveni and Zuidema's recent research on the astronomy of the Incas of Cuzco, located at 13° 50′ south, provides the best evidence for the significance of nadir solar passages.[13] Zuidema argues that the annual cycles of the sun, the moon, and the Pleiades were the three central celestial phenomena that were correlated together in such a way that one observed event announced the other. Urton demonstrated that the same observations are possible for the coast of Peru. In both regions, the series of astronomical observations and the agricultural cycle are conjoined.

The most significant feature of Inca astronomy is that the zenith and nadir were diametrically opposed in space and time. The zenith sunrise point on the eastern horizon and the nadir sunset on the western horizon formed the axis upon which the sun was believed to travel. Zuidema argues that nadir sunset was established by backsighting from the zenith sunrise position to form one of the *ceque* lines. The June solstice sunrise and the December sunset locations were likewise connected by a *ceque* line. The zenith and nadir dates at the latitude of Cuzco are six months apart (see FIGURE 1). The zenith-nadir dates were used to time the agricultural and ritual cycle. The nadir pair, August and April, are the beginning of planting and the beginning of harvest, respectively. Important rituals were celebrated on both dates. The February and October zenith dates, according to Sherbondy's ethnohistorical research, center upon rituals concerned with the control of water.[14] In February, a ritual was celebrated to signify that the earth was saturated with water and that a transition into the dry season was approaching. In October, a ritual was performed to signal the end of the first irrigation cycle; this period is a transition into the rainy season. Conversely, one pair of opposite dates, the August nadir, the beginning of the agricultural cycle, and the February zenith symbolically form the Andean *Axis Mundi*. The earth is still believed to open up on these dates to receive offerings. These two periods, opposed in time and space, are both propitious and dangerous. It appears to me that Andean people discovered an organizing principle of dialectical, reversible dualism that ordered their time, space, and society. The cultural focus seems to be on determining transitions from one cycle or state to another: from the dry season to the rainy season; from the sun's journey to the north to its journey to the south; from periods of abundance and prosperity to periods of scarcity and poverty. These periods were announced by specific series of celestial events and mapped onto space in axial sight lines (the *ceques*) that were observationally reversible (i.e., zenith sunrise and antizenith sunset) and semantically dualistic. I would like to suggest that a similar structural organization might be discovered for Mesoamerica.

In Mesoamerica, the prevalence of the concept of the *Axis Mundi* (see Coggins' paper) and the importance of the zenith passages for regulating the agricultural cycle suggest that the nadir passages may have more significance than previously believed. Moreover, both the Andean and Mesoamerican areas of complex cultural development are at latitudes where zenith and nadir passage dates are spaced such that they can be used in similar structural organizations.

Broda points out that, at Tenochititlan, the two zenith dates were

commemorated by important rituals in May and July. During the period in between these two dates, the sun entered the abode of the dead, which was believed to be in the north. I assume that this coincided with the sun's journey to the north, where it appeared to slow down before turning around during the June solstice to begin its journey towards its southern extreme. In addition, she discusses the coincidence of the disappearance of the Pleiades with the zenith passage of the sun on 17 May as contrasted with the nadir passage of the sun on 18 November, when the Pleiades were observed at the zenith. Thus, she argues for an "opposite symmetry" between the path of the sun and the path of the Pleiades. Climatologically, these two events were significant. The rains were announced by the disappearance of the Pleiades and the shadowless moment of zenith passage of the sun on 17 May. The dry season was heralded by the appearance of the Pleiades at the zenith and the sun at the nadir on 18 November. Therefore, one can think of the sun and the Pleiades as existing on an axis that announces the changing seasons. They form a dialectical, reversible, dual structure.

Likewise, Zuidema and Urton both argue that the multiple interactions of the zenith/nadir dates, the path of the Pleiades, and the phases and positions of the moon announce the changing seasons in Cuzco and on the coast of Peru. But whereas Broda finds an "opposite symmetry" prevailing between the course of the sun and that of the Pleiades, Zuidema and Urton find convergence. They both argue that the disappearance of the Pleiades at the end of April coincides with the nadir, which announces major transition periods. Zuidema argues that the disappearance of the Pleiades and the sun at the nadir symbolized the death of the sun, the moon, and the Pleiades. Beginning the harvest at this time in April caused Earth Mother to die as well. A period of rebirth was begun with the reappearance of the Pleiades (heliacal rise at dawn) in early June in Cuzco and on the coast of Peru. Notice that the cultural focus is on transitions and transformations of states, rather than on static moments. The logic is dialectical, not rationalistic. If we compare the interpretations of the disappearance of the Pleiades from the information given in Broda's, Zuidema's and Urton's paper, we get TABLE 1.

I have discussed these examples in some detail to illustrate that the same astronomical event (the disappearance of the Pleiades) is taken to be highly significant in both Mesoamerica and the Andes. However, this easily observable event is correlated with other highly significant events: the zenith and nadir of the sun. In order to gain further understanding of the cosmological meanings of this set of multiple observations, we have

TABLE 1

THE DISAPPEARANCE OF THE PLEIADES INTERPRETED

Multiple Astronomical Events Observed	Transition Announced	Location
May 17 Zenith sun Disappearance of the Pleiades ("opposite symmetry") or axis	Onset of rains Sun enters world of the dead	Tenochititlan (Broda)
April 26–46 Sun in nadir Disappearance of the Pleiades New moon (convergence)	Onset of harvest Death of the sun, the moon, the Pleiades, and Earth	Cuzco (Zuidema)
April 19–22 Sun in nadir Disappearance of the Pleiades (heliacal set at dusk) Next full moon (convergence)	Wet to dry season crops Feast to creator god	Huarochiri and Coast of Peru (Urton)

to examine the cosmological and astronomical context within which they occur. In the Andes, the reappearance of the Pleiades and the approach of the solstice in June announce a period of rebirth for the sun, the moon, the Pleiades, and the earth. What is the next cosmological sequence in Tenochititlan? In addition, do we find "symmetric opposition" in the activities of the mythic figures associated with the sun and the Pleiades in Aztec mythology? In Inca mythology, do the sun and the Pleiades have convergent roles or activities? These are further sets of questions that, once answered, would advance the study of the relationship between native astronomy and cosmology. We need to know the kind of metaphorical language used to express both opposed and convergent astronomical events.

Metaphors relate at least two phenomena together in figurative expression. The multiple interactions of celestial bodies that are observed in order to determine major transitions are better expressed in the language of metaphor, which expresses movement, transition, and reversibility or reflection. For example, the metaphors that come to mind from the papers in this conference include: weaving (Klein), hydraulics (Hugh-Jones, Richel-Dolmatoff, and Urton), the refraction of light in crystals (Reichel-Dolmatoff and Zuidema), and mirrors (Klein). Even the sym-

bolic forms that at first glance seem to be static, in reality express dialectical concepts: the *ushñu* (Zuidema), the serpent-mountain (Townsend), the caterpillar-jaguar (Hugh-Jones), and volcanoes (Coggins). I am reminded of the session in the Hayden Planetarium when Aveni asked Franklin to speed up the motion of the sky. The effect, as we watched the Milky Way change, was like watching a giant undulating snake move across the sky. We were able to perceive what the language of metaphor attempts to capture when apprehending the spatiotemporal relationships of tropical American cultures.

What we were attempting to capture in the planetarium was a dynamic process that somehow embodies temporal order. The ancient astronomers of tropical America attempted to capture these same processes of structural order in settlement plans and architectural and ritual space. We might label their attempt relational, or dialectical geometry. The paper by Aveni and Hartung illustrates the concern that Mesoamericans had for obligating the perceiver to focus upon the interaction of celestial forces by constructing the environment of ceremonial space around the principle of what Aveni and Hartung have called inter-building relationships. I think that the astronomer-architect-priests were attempting to assure that the dynamic (or dialectical) perspective they had discovered would be maintained from generation to generation. Likewise, the *ceque* lines of Cuzco, which embody the organizational principle of dialectical, reversible dualism, are a means of perpetuating the epistemological discovery that there exists a dynamic relationship between time and space. For example, Dearborn and White's paper confirms Zuidema and Urton's arguments concerning the relationship between the zenith solar passage, the path of the Pleiades (its heliacal rise and set), and the June solstice. The construction of the Torreón obligates the observer to adopt a perspective that focuses upon the relation of one transition of time to another instead of pinpointing the precise date of an astronomical event. I would suggest that such a dynamic perspective is shared by the cultures of the American tropics as culture confronts nature in the reversible world of the tropics. Through the application of dialectical logic, the cosmologies of these cultures construe the contradictions perceived in nature as necessarily interdependent. The contradictions can never be resolved because cosmic order is maintained by the dialectical tension resulting from the reversible relationship pertaining between opposed elements.

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